1771

Dialling Universal.

SHEWING

By an easie and speedy way, how to describe the Houre-lines upon all sorts of Plains in any Latitude whatsoever: Performed by certain *SCALES* set upon a small portable *RVLER*.

The Second Edition furnished with these varieties.

I. REFLEX DIALLING: Teaching how to describe Houre-lines on the Cieling of a Room, how irregular soever: The Glasse lying either Parallel to the Horizon, or oblique thereunto.

II. To finde the necessary Requisites belonging to all Plains, as the *DECLINATION*, *AZIMVTH*, the height of the *STILE*, The *INCLINATION* of *MERIDIANS*, *&c.* Severall wayes.

III. Severall TABLES ready calculated, being usefull in the Art of DIALLING.

WITH

AN APPENDIX:

Shewing the Use of the *SCALES* in resolving of the most usefull Questions appertaining to *Astronomie*, *Navigation* and *Geography*.

By GEORGE SERLE, *Student in the Mathematicks.*

LONDON,

Printed by *W. Leybourn*, for *Thomas Pierrepont*, at the Signe of the *Sun* in St. *Pauls* Church-yard.

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NICVM

MVSEVM
BRITAN
NICVM

To The READER.

Courteous Reader,

HAVING some yeares since set down for my owne use and practice some Instructions, and framed some Scales for making all sorts of Plain *Dials* with centers, deduced from Mr. *Fosters* Quadrant; as also some other Scales of my own invention, for making of

Far-declining Verticalls, and Polar Decliners; and having communicated it to a Friend, an able *Mathematician*; he incouraged me to Print it, which elſe had never been done: and indeed I could have wiſhed it had been (at leaſt) delayed, by reaſon the Book and Inſtrument (as it then came forth) was not ſufficient fully to direct in the buſineſs of *Dialling*; there having been no Rule preſcribed for finding the Suns Azimuth: That want is now ſupplyed (and will be ſufficient for *Dialling*, in any part of *Great Britaine*) by a particular Diagonall Scale ſet on the Ruler.

Again, There are four other Diagonal Scales on the Ruler, which ſerve for finding the neceſſary requiſites for all ſorts of Plain Dialls, which muſt be known before the hour-lines can be drawn.

Moreover, You have the nature of *Reflex Dialling* largely enough Treated of, and illuſtrated, with ſeveral varieties of Examples and Schemes; deduced from Mr. *Haltons* ingenious invention, briefly mentioned in his Letter

Letter to his Friend, at the end of Mr. *Foſter's Miſſelanies*: as alſo two ſeveral wayes for drawing the houre-lines on the Floor of a Room, from the Suns beames, paſſing through a ſmall hole in any Pain of Glaſs in a window.

And laſtly, You have a ſhort *Appendix*, ſhewing how to reſolve the moſt uſual and uſefull Queſtions in *Aſtronomy*, *Navigation*, and *Geography*, by the Scales on the Ruler; partly by extention of the Compaſſes on one Scale, and meaſuring its extent on another; and partly by an eaſie way of Protracting a Right Lined Right Angled Figure on Paper: and this to be done by ſuch as are not verſed in the Logarithms, but for ſuch as are, (and deſire to uſe the Cannon,) they will find the proportions ſet down, ſuitable to the propoſitions, onely he muſt be carefull that he miſtake not Sine or Tangent, for Coſine or Cotangent: To conclude, I ſhall deſire you to mend the faults with a Pen, that are noted in the *Errata*, and ſuch others as you may finde; and accept of my Paines and Good-

will herein, which will be an encouragement to me to Study the Production of somewhat else, more worthy your Acceptance, as God shall be pleased to afford ability and opportunity: I remaine

A Friend,

And Well-wisher,

To all that affect the Mathematicks,

George Serle.

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By the ſcales, of ſines, tangents, and equall parts.

ERRATA.

PAge 39. line 3. & line 14. Reade E A C, p. 40. l. 15. & l. 20. reade E A C. p. 68. l. 4. r. Reclination; p. 72. l. 26. ſtrike out here following: p. 73. l. 1. r. 51. 51. p. 75. l. 9. r. reclination: p. 79. l. 13. r. done: p. 80. l. 8. r. Tropick of Capricorne: l. 34. r. for: p. 106. l. 15. r. ſignes. p. 11. l. 12. add 52.

1. Note that Page 18. Chap. 11. firſt Example, you muſt reade, inclining Northward: 21. 56. I deduct 24. 56. out of 38. 28. p. 19. ſecond Example of the ſame Chap. r. Incline Southward 38. 4. theſe, 28. 4. I add to 38. 28.

2. Note, that divers of the Sthemes have the two P's out of a like bigneſs, but that which ſignifies the Pole of the Glaſs ought to be the great P.

Imprimatur.

Tho. Grigg. R. in Chr. P. ac Dno.

Febr. 18. 1663.

D. Humf. Epiſ. Lon.

a. ſac. dom.

DIALLING Universall.

CHAP, I.

The deſcription of the Scales on the Ruler.

THe firſt Scale is a Scale of ſix Hours, each houre divided into halves and quarters of hours, being proper for Dials that have no declination: as the Horizontall, the direct North or South, whether upright or inclining.

Moreover, each hour is ſubdivided into as many unequal parts, as the length of the Scale wil permit: this Scale is of ſpecial uſe in deſcribing all other Dyals that have Centers; where the height of the ſtile above the Plain is not leſs then 10 degrees: when that happens, there are other Scales to perform it with ſpeed and exactneſs enough.

This Scale hath the letters (*Hour*) at the beginning.

The ſecond Scale is a Scale of 90 degrees, anſwerable to the Scale of Hours, every degree being ſub-divided into as many parts as quantity will give leave. This Scale is known by the letters (*Incl.*) at the beginning. Note that the firſt and ſecond Scales together, ſhew how many degrees and minutes of time are contained in any number of degrees and minutes of the Equinoctiall under 90, *& contra.*

Example. Againſt 20 degrees on the ſecond Scale, you ſhall finde on the firſt Scale 1 houre 20 minutes: and againſt 50 degrees on the ſecond Scale, you ſhall finde 3 hours 20 minutes on the firſt Scale, and ſo of any other number what ever, if carefully computed.

The third Scale is a Scale of Latitudes, known by the letters (*Lat.*) at the beginning.

The fourth and fifth Scales are two Scales of Hours of different leugths, either of which ſerve to make all Direct Meridian or Polar Dials, alſo all Polar Dials that Decline.

Both theſe Scales together, ſerve for the ſpeedy drawing the Houre lines on all ſorts of Plains, where the height of the ſtile is but ſmall, and the centre of the Dial left out, Theſe Scales are known by the letters (*Pol.*) at the beginning.

There are alſo two Scales of Chords, a greater and a leſſer, ſerving to protract and meaſure angles.

The Scales *hereafter mentioned are ſince added.*

Two Diagonall Scales, a greater and a leſſer, fited for the finding of the *Suns* Azimuth from the South in any part of *England*, at any Altitude of the Sun. The greater of theſe Scales is known by the letters (*Az. A.*) at the beginning, and the leſſer of them by the letters (*Az. B.*)

Next theſe *Scales* is a *Scale* of Verſed *Sines*, to be uſed with the Azimuth Scales.

Then

Then you have four other Diagonall Scales, which give the neceſſary requiſites for all Vertical declining, and Meridian inclining plains, for any part of *England*.

The firſt gives the height of the ſtile above the ſub-ſtile, for all Vertical decliners, and is known by the letters (*Stile Ver.*) at the beginning.

The ſecond gives the inclination of Meridians for all Vertical decliners, known by the letters (*Incl. Ver.*) at the beginning.

The third gives the ſtiles height above the ſubſtile for all meridian incliners, noted with (*Stil. Mer.*) at the beginning.

The fourth Diagonal Scale gives the Inclination of meridians for all meridian inclining plains, and is diſtinguiſhed from the reſt by theſe letters (*Inc. Mer.*) at the beginning thereof.

To theſe is joyned a Scale of Natural Sines, Secants and Tangents, to be uſed with theſe Diagonal Scales, and being of a like Radius with them: As alſo a ſmall Scale of equal parts to the ſame Radius, the Tangent Scale being the laſt of the four, for the advantage of having as many degrees put on as the length of the Ruler will permit. Theſe Scales are diſtinguiſhed by theſe letters, (*Si.*) for Sines, (*Se.*) for Secants, (*Eq.*) for Equal parts, and (*Ta.*) for Tangents.

At the end of the firſt mentioned Scales I have put on the Degrees of a Quadrant, which may ſerve to finde the Declination or Inclination of a Plain, the centre of which Quadrant is *A*. But if in taking the Declination of a plain, the Sun be on the contrary hand, ſo as that you cannot uſe that Quadrant, in ſuch caſe the arch *AC* is the limb of another Quadrant, whoſe centre is *B*, and whoſe degrees are numbred in the arch from 00 deg. to 90.

Again, Within the ſaid Quadrant is framed a particular Diagonal Scale, by which may be drawn all Horizontal or Vertical Dials, for any Latitude between 34 and 56 degrees.

Moreover, There being a ſpare place at the end of the Verſed lines, I have put on a Scale of Chords to 60 deg. being of the ſame Radius with the Sines, Secants & Tangent, which is of good uſe, when the Tangent or Secant required ſurmounteth the Scale, it may be found by protracting a Quadrant on paper, and ſeting off the degrees thereon, and from the centre, through the point aſſigned on the Quadrant, to draw a line to touch the Tangent line, which ſhall give the Secant and Tangent required: This I ſuppoſe to be already wel known to the young practicioner.

And laſtly, On the edge of the Ruler, there is a large Tangent put on, numbred from 00, to 63 deg. 31 min. which with a Gnomon fited into a hole made at the beginning thereof, equal in length to the Radius, or Tangent of 45 deg. of the ſame Scale, may ſerve for takeing the height of the Sun.

And if you pleaſe, On the other edge may be put on, a Scale of Declinations, with a Zodiack, whereby, the Suns place being known, the Declination may be found, without the help of the Table of the Suns Declination for every day.

CHAP. II.

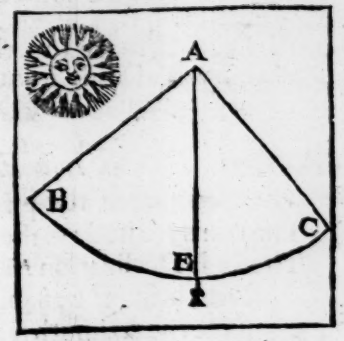
To take the Altitude of the Sun.

FIx the Gnomon into the hole made at the beginning of the Tangent on the edge of the Ruler, and hold the Ruler perpendicular to the Horizon, with the ſaid edge towards the Sun, ſo wil the ſhadow of the ſaid Gnomon fall on ſome part of the Scale; marke where it falleth, for that is the Altitude required.

Otherwiſe.

You may take a ſmooth Board, and on it draw two lines at right angles, as the lines A B and A C, and with

with 60 degrees of a line of Chords, draw the arch B C. then in the centre A, fix a ſtreight pin or needle, on which hang a thrid and plummet, Then lift up the board towards the ſun, in ſuch manner, as that the ſhadow of the pin or needle may fall on the line A C, and where the thrid ſhall cut the arch BC, make a mark, ſo the arch B E being meaſured with the ſame Chord that you drew the arch BC, wil ſhew the altitude of the ſun at that time.



CHAP. III.

How to finde the Suns Azimuth at any time.

DRaw the lines A B and A C, at right angles to one another, Then conſider the Latitude of the place and altitude of the ſun, and with your compaſſes, fixing one foot at the beginning of the parallel proper for the Latitude in the Diagonal Scale (*Az. A*) extend the other to the ſuns altitude in the ſame parallel, and ſet off that extent in the line A B, from A to B. Again, extend the compaſſes in the other Diagonal ſcale (*Az. B*) from the beginning thereof (reſpecting ſtill the parallel of the Latitude) to the altitude, and place that extent in the line A C, from A to C, and draw the line C B, then by the Table of the ſuns Declination or Scale & Zodiack on the Ruler, find the Declination for that day, and fixing one foot of the compaſſes in the point of the tropick of ♋, in the ſcale of Verſed ſines, extend the other foot to the ſuns Declination, accounted from the point of *Aries* or 90 degrees downward towards ♋ if the declinatioe be North, elſe beyond ♈ ♎ or 90 deg. upwards towards the Tropick of ♑ if the declination be South, and ſet that extent off on the line A C

from

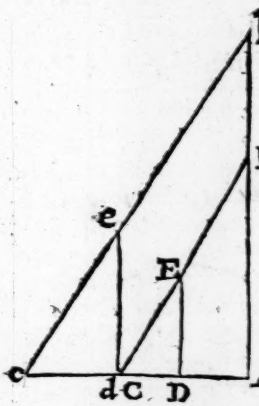
from A to D, & in the point D rais a perpendicular to A C and parallel to A B, and where that perpendicular shall cut the line C B, make a mark, as at E: Lastly, measure D E in the versed Scale from the beginning, and it will give you the quantity of the Azimuth from the *South*.

First Example.

The Latitude of the place	51 *deg.*	32 *min.*
The Suns Altitude in the Fore-noon	35	00
The Suns Declination *North* for that Day, being the 28. of *March*	07	07

To finde the Azimuth from the South.

Having, by the direction aforesaid, drawn the lines A B and A C, at right angles, make A B equal to the altitude, 35 deg. taken out of the greater Diagonal Scale (*Az. A.*) respecting the parallel proper for the Latitude, 51 degrees 32 minutes, and make A C equall also to 35 deg. taken out of the lesser Diagonall Scale (*Az. B.*) respecting also therein the Proper parallel, and draw the line C B. Then take out of the scale of Versed-sines the Declination of the Sun, by fixing one foot of the Compasses in the point of ♋, and extending the other foot to 7 de. 7 min. counted downwards from the middle of the Scale towards ♋, (because the Declination is North) and that extent place from A to D, and draw D E parallel to A B; so D E being measured in the Scale of Versed-sines, from the beginning thereof, will shew the Azimuth to be 50 deg. 21 min. from South towards the East.



Second

Second Example.

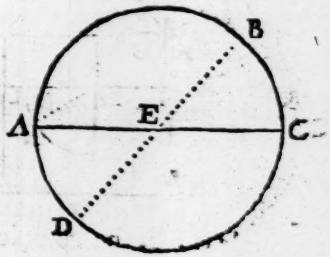
The Latitude of the place	51 *deg.*	32 *min.*
The Suns altitude in the Afternoon	10	00
The Suns declination *South*, for that day being the 20. of *February*	6	54.

To finde the Azimuth from the South.

As in the second part of the Diagram, make *A b* equal to the altitude of the Sun, 10 deg. taken out of the greater Diagonal scale (*Az. A*) and *A s* equal to 10 deg. of the Diagonal (*Az. B*) respecting in both the parallel for the Latitude 51 deg. 32 min: and draw *C B*. Then take the declination of the sun out of the Versed-sines, by fixing one foot of the Compasses in the point ♋, and extending the other to 6 deg. 54 min. beyond the middle of the *S* cale or 90 towards ♈, (the Declination being South) and that extent place from *A* to *d*, and draw *d e* parallel to *A b*, so *d e* measured in the Versed-sines, gives the Azimuth from South towards West 65 deg. 17 min.

CHAP. IV.

To draw a Meridian Line on an Horizontall Plain.



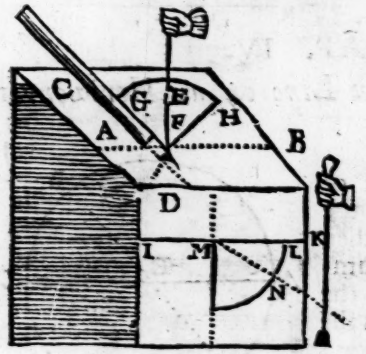
With your Line of Chords describe the Circle A B C D, then holding up a thrid & plummet, so as the shadow of the thrid may passe through the center E, draw the line of shadow D E B: Take then the altitude of the Sun, (or rather,

rather, let another take it at the same instant) which suppose to be 35 deg. as in the first Example of the last Chap. that done, get the Suns Azimuth, which in the same Example is 50 deg. 21 min. from South towards East, these 50 deg, 21 min. I take out of the line of Chords, and set from the point D, Southwards to A, drawing the line A E C for the Meridian line.

CHAP. V.

To finde the Inclination of a Plain, by a Quadrant, an ordinary smooth Board, or by the degrees of a Quadrant at the end of the Ruler

THe Inclination of a Plaine is the Angle which it maketh with the Horizon. Draw first an Horizontall line as A B, and cross it with the Perpendicular C D, then apply a Quadrant to the Verticall line C D, on a Ruler, as the figure directeth you, and holding up a thrid and plummet, so as that the plummet may, by meanes of the Ruler, play under the centre of the Quadrant, the thrid passing through the centre, observe the degrees cut in the limb, and count them from that side of the Quadrant which is perpendicular to the plain, & that shall be the Inclination of the Plain, as the angle H F E, the complement whereof E F G, is the angle of Reclination of that plain from the Zenith.



In-

Instead of a Quadrant you may make use of a Board having one smooth edge, as the edge G F, and describing the arch G E H, with 60 degrees of your line of Chords, drawing F H perpendicular to F G, and measuring the arch E H with the same Chord.

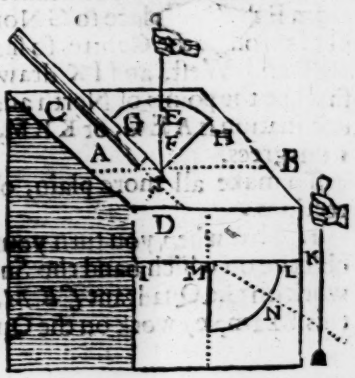
Or Lastly, This may be done very well with the degrees at the end of the Ruler, placeing the Ruler so, as that the graduated end may stand off of the plain, for the thrid and plummet to play.

CHAP. VI.

To finde the Declination of a Plain, by help of a Quadrant, an ordinary Board, or by the degrees at the end of the Ruler.

THe Declination is alwayes reckoned in the Horizon, and is the angle contained between the line of East and West, and the Horizontal line upon the plain. Now to get the declination, two observations are required. First, the Horizontal distance of the Sun, from the Horizontal line of the Plain. Secondly, the Suns Altitude.

Draw first an Horizontall Line, as the Line I K, then apply thereto the side of a Quadrant, holding it parallel to the Horizon, then hold up a thrid and plummet, so as the shadow of the thrid may passe through the centre of the Quadrant, then observe the degrees cut off by the thrids shadow on the limb, & reckon them from that



C side

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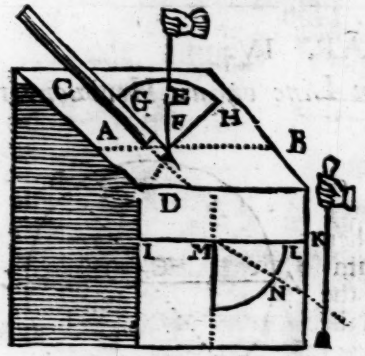

In-

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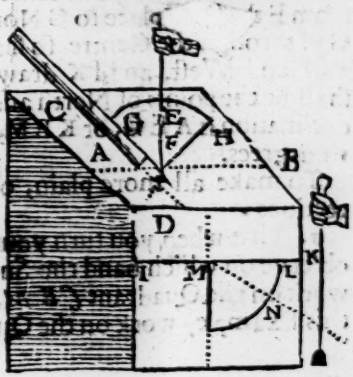
THe Declination is alwayes reckoned in the Horizon, and is the angle contained between the line of Eaſt and Weſt, and the Horizontal line upon the plain. Now to get the declination, two obſervations are required. Firſt, the Horizontal diſtance of the Sun, from the Horizontal line of the Plain. Secondly, the Suns Altitude.

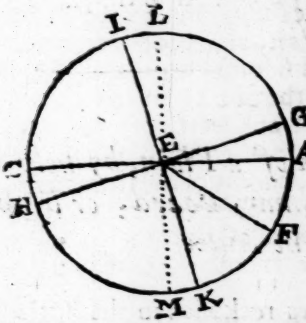
Draw firſt an Horizontall Line, as the Line I K, then apply thereto the ſide of a Quadrant, holding it parallel to the Horizon, then hold up a thrid and plummet, ſo as the ſhadow of the thrid may paſſe through the centre of the Quadrant, then obſerve the degrees cut off by the thrids ſhadow on the limb, & reckon them from that



C ſide

side of the Quadrant, that is parallel to the Plain, as the angle L M N, that is the Horizontall distance.

Secondly, take the Suns altitude, and find his Azimuth, these compared together, will help you to the Declination, as may be plainly demonstrated by this second Figure.



With the Radius of the line of Chords, describe the Circle C L A M, which shall represent the Horizontall Circle, and draw C E A, for the Horizontall line of the Plain and L E M at right angles thereto; then with the same Chord, set off the Horizontall distance L M N of the former Figure (which in this Example shall be 35 degrees) from A to F, then having taken the Suns altitude by the second Chapter, find by the third Chapter the Azimuth from the South, which in this Example shall be 40 degrees, and seeing the observation was in the forenoon, is 40 degrees from South towards East, or 50 degrees from East towards South, these so take out of your same Scale of Chords, and place from F th[illegible]s place to G Northward, and draw the line G H through the Centre, so shall G H be the true points of East and West, and I K drawn at right angles to G H, shall be the points of North and South. Now the angle of declination is A E G, or K E M, which in this Example is 15 degrees.

To make all more plain, observe those following directions.

1. That when you turn your face to the Plain, you must observe on which hand the Sun is, if on the right hand, work on the Quadrant *C E M*, if on the left hand (as in this Example) work on the Quadrant *A E M*. Then to find

find to what Coast the Plain declineth, whether to the East or West, consider which of the points H or G is under the Horizontall line C E A, and what they signifie, as in this Example, H signifies the West, and G the East point; so H being under the Horizontall line, I conclude that the Plain declineth West.

2. The Horizontall distance may be found by the degrees at the end of the Ruler, by applying the Ruler to the Plain, respecting the Coast the sun is on, if it be on your right hand, your back towards it, and your face towards the Plain, turn the graduated side that way, and A is the Centre of that Quadrant; if the Sun be on the left hand, then turn the Rule quite about and let the pricked arch be the Quadrant, and B its Centre, then with a small thrid and plummet held up, and the shadow of the thrid made to pass through the Centers A or B, observe the degrees, &c. as was shewn in the application of a Quadrant to the Plain.

3. That a board having one smooth edge, may serve in stead of a Quadrant.

4. That if the Azimuth of the Sun be taken at such time as the shadow of the thrid shall fall on the Horizontall line C E A, or a line parallel thereto, then the declination will be equal to the Suns Azimuth from East or West: if at such time as the shadow shall fall on *E M*, then the declination shal be equal to the Azimuth of the Sun from South, East or Westward, according as the observation was made before or afternoon.

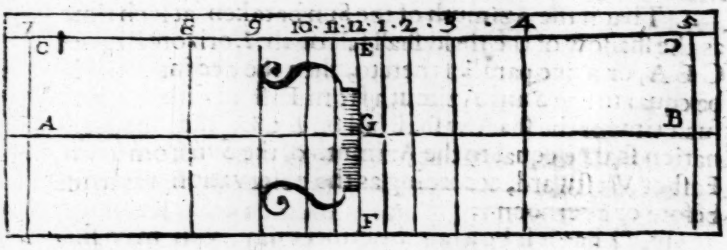
5ly. That if it be a fair Summers day, you may find what altitude the Sun wil have, when he comes to be due East or West (as by the 4th Prop. of the first Chap. of the Appendix) and expect til it come to that Altitude, and then the declination shal be equal to the angle contained between the Horizontal line *C E*, and the line of shadow, with the angle A E F.

CHAP.

CHAP. VII.

To draw a Polar Diall.

A Direct Polar plain is that which is parallel to the houre-circle of 6. First draw the horizontal line, A B, with its parallel C D, then draw the perpendicular E F, which shall serve for the Substile and houre of 12. Then repair to either of the *Scales* known by the letters (*Pol.*) and fixing one foot of the Compasses at the beginning of the said Scale, extend the other foot to the houre of 1. set off that extent from E to 11, and from E to 1, as also from G both wayes on the line A B, and draw the lines of 11 and 1, parallel to the substile E G F: Then again extend the Compasses from the beginning of the Scale to two hours, set off that extent from E to 10, and



from E to 2, also from G both wayes, and draw the hours of 10 and 2: Then extend the Compasses from the beginning of the Scale to 3, and set off that from E to 9, and from E to 3, and draw the hours of 9 and 3 parallel to the former. Then extend the Compasses from the beginning of the Scale to 4, and set off that extent from E to 8, and from E to 4, also from G both wayes, and draw the hours of 8 and 4. Lastly, Extend the Compasses

paſſes from the beginning of the Scale to 5, and ſet off that extent from E to 7, and from E to 5, alſo from G both wayes, and draw the hours of 7 and 5, ſo have you all the hours proper for this plain.

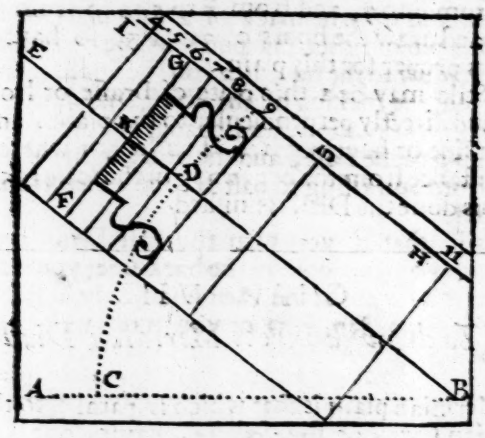
The Stile may be a thin plate of Braſſe or Iron, that muſt ſtand directly perpendicular to the plain; and in the Subſtilar line or houre of 12: The length whereof muſt be the diſtance from the beginning of the Scale to the hour of 3. This done the Diall is finiſhed.

CHAP. VIII.

To draw an erect Meridian Diall.

A Meridian plain is that which is paral'el to the Meridian Circle of the Sphere, having one face to the East, the other to the West, in each of them the Stile and Subſtile will be parallel to the plain, and the hour lines parallel one to the other, as in the direct Polar of the former Chapter. Our Example ſhall be of a Meridian Diall with the face to the East, in the Latitude of 51 deg. 32 min. and is thus deſcribed,

Draw firſt the Horizontal line A B, then with the Radius of your line of Chords, one foot fixed in B, with the other draw the arch C D, and in the arch C D, ſet off the height of the Æquinoctiall, 38 deg. 28 min. from C to D, and draw the line B D E, then in ſome convenient place of the line B E, as at K, draw the line G K F, at right angles to the line E D B, ſo ſhall G F be the ſubſtile and hour of 6. Then to E D B, draw a parallel as I H.



Having ſo done, work as in the laſt Chapter was ſhewn, by taking the diſtance from the beginning of either of the Polar Scales to 1 hour, ſetting that extent from G to 5, and from C to 7, and on its parallel E B, from K both wayes, and draw the hours of 5 and 7, parallel to the Subſtile and hour of 6: Then take in your compaſſes the diſtance from the beginning of the Scale to 2 hours, and ſet it off from G to 4, and from G to 8, and alſo from K both ways, and draw the hours of 8 and 4, parallel to the other; ſo you have no more hours to ſet off towards I, being 4 is the houre of Sun riſing, but proceed to ſet off the reſt of the hours towards H, as you did the other, takeing in your compaſſes the diſtances from the beginning of the Scale to 3, 4, and 5, ſetting each diſtance off reſpectively from G towards H, at 9, 10, and 11, and alſo from K towards B, and draw the hours of 9, 10, 11: and ſo you have all the hours proper for this Dial.

The diſtance from the beginning of the Scale to the houre of 3, gives the height of the Stile, which muſt ſtand

ſtand directly over the Subſtile, making right angles therewith, and may be made of a thin plate of Iron or Braſſe, or a pin of either ſharpned, whoſe extremity muſt give the ſhadow to the hour lines on the Diall.

Note, that the making of the Weſt Dial differeth from this only in its ſituation, and changeing the hours, this Dial looking to the Eaſt, and the other to the Weſt: this ſerving from Sun riſing to paſt 11, the other from before 1 to Sun ſet.

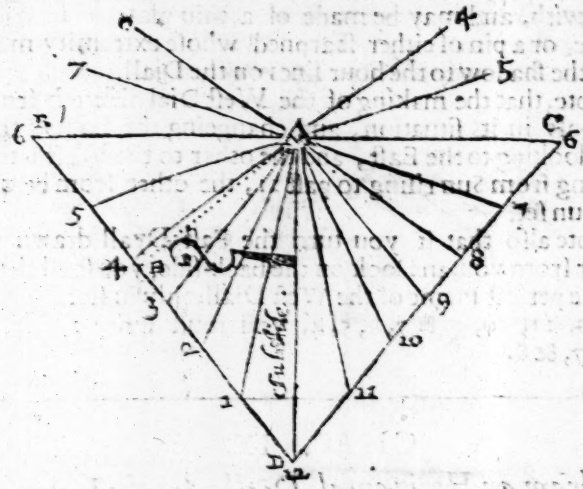
Note alſo that if you turn the Eaſt Dyall drawn in Paper from you, and look on the back-ſide, you ſhall there ſee the perfect forme of the Weſt Diall, only in ſtead of the hours, 11, 10, 9, 8, 7, 6, 5, 4, you muſt write 1, 2, 3, 4, 5, 6, 7, & 8.

CHAP. IX.

To draw an Horizontal Diall, for the Latitude of 51 deg. 30 min.

AN Horizontal Plain is that which is parallel to the Horizontal Circle of the Sphere, to draw the hours proceed thus. Draw a line at length, as B A C, then repair to your Scale of Latitudes, known by the letters (*Lat.*) at the beginning, where fixing one foot of your compaſſes, extend the other to 51 deg. 30 min. and ſet off that extent from A to B, and from A to C, and draw the lines A B, A C, then open your compaſſes to the length of the whole Scale of hours, or firſt Scale, and with that extent, one foot fixed in B, with the other foot make an arch at D, then with the ſame extent, one foot fixed in C, with the other croſs that arch at D, and draw the lines B D and C D, alſo draw the line A D for the Subſtile, and houre of 12.

This



This done, extend your Compasses from the beginning of that *Scale* to 1 hour, and set off that extent from D to 1, and from D to 11, also the same extent must be set from B to 5, and from C to 7. Then extend your Compasses from the beginning of the said *Scale* to 2, and set it off from D to 10, & from D to 2, also from B to 4, and from C to 8, Lastly, extend your Compasses from the beginning of the said *Scale* to 3, and set that off from D to 3, and from D to 9: so have you points for 12 hours. Now lines drawn from the centre A to each of those points, shal be the hours required.

Note, That the hours of 4 and 5 in the morning, and 7 and 8 in the evening, are to be drawn through the centre, And if you desire the halves and quarters, they are to be drawn in all respects as the hours.

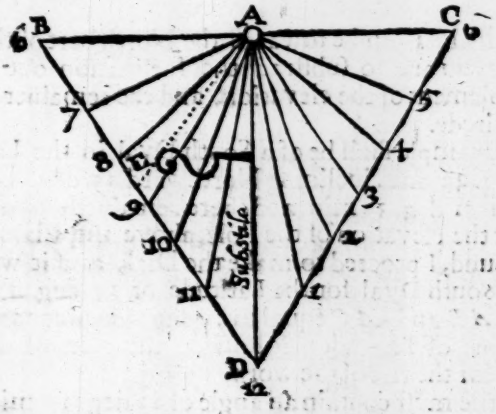
With your line of Chords make an angle of 51 degrees 32 minutes, for the Stile or Cock of your Dial, and set it over the *Sub-stile* A D at right angles, as the angle E A D in the Diagram, and the Dial is finished.

CHAP

CHAP. X

To draw a Dyal on an erect direct Verticall Plain.

A Vertical Plain is that which is parallel to the prime Vertical Circle of the Sphere, it hath two faces, one to the South, the other to the North; our example shall be of a South Plain in the latitude of 51 deg. 32 min. The making of this Dyal differeth little from the Horizontal, only you must take notice, that this Plain respecteth the South Pole, which Pole is elevated thereon 38 deg. 28 min, being the Complement of the Latitude, and so much you must take out of your Scale of Latitudes, and



set off from A to B, and from A to C, then take in your Compass the whole Scale of hours or first Scale and with that extent one foot fixed in B, with the other make an arch at D; again with the same extent one foot fixed in C, with the other crosse the arch at D, and draw the lines B D and C D, also A D for the Substile and hour of 12.

Finish the Dyal in all respects as you did the Horizontal, only observe, that whereas in that Dyal, the hours of 1, 2, 3, &c. were set off on the line B D, towards the left hand, the same hours must in this Dyal be set off on the line C D, towards the right hand.

The Stile E A D must contain an angle of 38 deg. 28 min. being the Complement of the Latitude, and must stand directly over the Substile A D. For the North face, the Centre must be below and the stile point upward, the hours fit for that Plain are those of 4, 5, 6 and 7 in the morning, and 5, 6, 7 and 8 in the evening.

CHAP. XI.

How to draw a Verticall Inclining Dyal.

IF the Inclination be towards the North part of the Horizon, you are to substract the Inclination out of the Complement of the elevation, and the remainer is the new Latitude.

Our Example shall be of a South Dyal in the Latitude of 51 deg. 32 min. inclining Northward 25 deg. I deduct 25 out of 51 deg. 32 min. and there remaineth 13 deg. 32 min. for the elevation of the Pole above the Plain; that being found, I proceed to make the Dial, as if it were an upright South Dyal, for the Latitude of 13 deg. 32 min. making *A B* and *A C* equal to 13 deg. 32 min. taken out of the line of Latitudes, following the rules of the last Chapter for the rest of the work.

The stile must contain an angle of 13 deg. 32 min. and must be set directly over the Substile *A D*, and the Dyal is finished.

But if the Inclination be towards the South part of the Horizon, then adde the Inclination to the Latitude, and the sum is the elevation of the Pole above the Plain, if the

sum.

ſum exceed 90, take it out of 180, and the remainer is the elevation of the Pole above the Plain.

Example. In the Latitude of 51 deg. 32 min. a Plain found to incline Southwards 15 deg. theſe 15 deg. I adde to 51 deg. 32 min, and the ſum is 66 deg. 32 min. and that is the elevation of the Pole above the Plain; ſo obſerving the former directions, you may proceed to make the Dyal, as is before taught.

CHAP. XII.

How to draw an Equinoctial Dial.

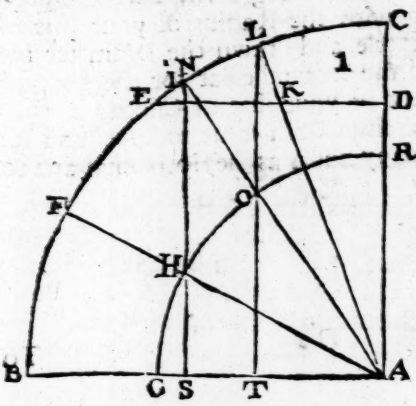
AN Equinoctial Plain is that which is parallel to the Equinoctial Circle of the Sphere: Make A B and A C equal to the whole line of Latitudes, and proceed as if you were to make an Horizontal Dyal, and ſet up a Pin of Braſs or Iron ſharpened, and of any convenient length in the Centre of the Dial, perpendicular to the plain.

But the beſt way to draw this Dyal, (being the hours are equidiſtant) is to divide 360 degrees by 24, the Quotient is 15; ſo having with the Radius of your line of Chords, deſcribed a Circle, and drawn the Diameter for the 2 hours of ſix, and the perpendicular for the hour of 12, take 15 degrees out of your line of Chords, and ſet them off in the arch or circle from hour to hour, and let this Dyal contain as many hours as the Horizontal, and be ſo numbered.

CHAP. XIII.

To find the height of the Pole above the Plain, the distance of the Substile from the Meridian, and the inclination of Meridians, for upright declining and Meridian inclining Dyals; as also what ever else is necessary to be found for all other Dyals hereafter treated of, before the hour lines can be drawn.

CONsidering that the Ruler (for finding of the Azimuth and altitude of the Sun) is already furnished with Scales of Sines and Tangents: I thought good (with the addition of some diagonal Scales) to set down a way for the finding of the necessary requisites above mentioned, with more ease and expedition, then that which I borrowed from *Mr. Stirup*, which nevertheless is an excellent way, (being it requires only a line of Chords) and is the subject of this Chap. leaving the Practitioner to make use of which he pleaseth.



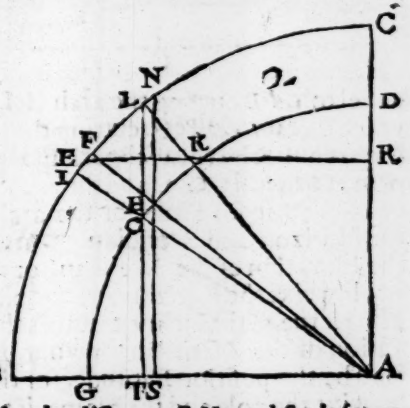
The first Example shal be of a plain in the Latitude of 51 deg. 32 min. declining from the South towards the East 28 degrees, as by the first Diagram of this Chapter is demonstrated.

Describe a Quadrant as *A B C*; set off the Latitude 51 deg. 32 min. from B to

to E, and draw E D parallel to A B : Then take the distance D E with your compasses, setting one foot in A, with the other draw the arch G H O R ; then set off the declination 28 deg. from B to F, and draw F A, cutting the arch G R in the point H, through which point H, draw the line S H N ; so shall C N be the height of the Pole above the plain, and is 33 degrees 20 min. Then take the distance H S, and set it off from D to K, and draw the line *A K L*, so shall C L be the distance of the Substile from the Meridian, 20 deg. 30 min.

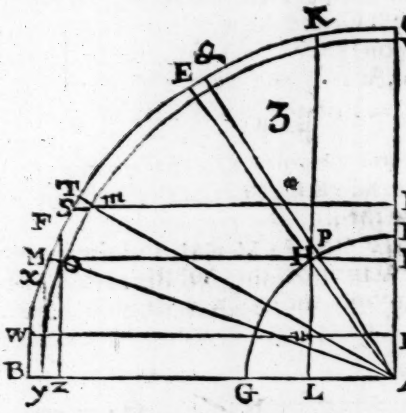
Lastly, from the point L draw L T, cutting the arch G R in O, and draw *A O I*, so shall C I be the inclination of Meridians, 34 deg. 12 min.

The second Example shal be of a Meridian plain in the Latitude of 51 deg. 32 min. inclining 40 degrees. This work differs little from the former : Describe a Quadrant as *A B C*; set off the Latitude 51 deg. 32 min. from C to E, & draw E R parallel to *A B*, then with the distance E R, draw the arch G H D ; & set off the inclination 40 degrees from B to F, and draw *A F*, cutting the arch G D in H, & draw S H N: so shal C N be the elevation of the pole above the plain, 36 deg. 49 min. *A*gain, take the distance S H, and set it from R to K, and draw *A K L*, so shall C L be the distance of the Substile from the *M*eridian, 38 deg. 57 min. Lastly, draw *L T*, cutting the arch G D in O, and draw *A O I*, so shall *C I* be the inclination of *M*eridians, 53 deg. 26 min.



The third Example shal be of a declining inclining plain in

in the Latitude of 51 deg. 32 min. declining from South towards East 34 deg. and inclining to the Horizon 24 deg. First draw the Quadrant *A B C*, and set off the declination from *C* to *E*, then draw *A E*; again, set off the inclination 24 deg. from B to F, and draw F Z parallel to A C; then draw the arch G H I, cutting A E in H, and through the point H draw K L, cutting the arch C B in K, take the distance H L, and set it in the line F Z from Z to O, & draw the line *A O M*, cutting the arch B C in *M*, from which point *M*, draw *M P N* parallel to *A B*, cutting the arch G I in P, through which point P draw *A P Q*, cutting the arch B C in Q; so shall the arch B K be the inclination of the plain to the *Meridian*, 76 deg. 51 min. and the arch B Q the *Meridians* ascension 58 deg. 22 min. or the arch of the Plain betwixt the Horizon and *Meridian*. And the arch *B M* shall be the Elevation of the *Meridian*, or the arch of the *Meridian*, betwixt the Horizon and the plain, 20 degrees 16 min. Now if the plain incline towards the South, adde the elevation of the *Meridian* to your Latitude, and the sum shall be the position Latitude, or the arch of the *Meridian* betwixt the pole and the plain; if the sum exceed 90, take it out of 180, and that which remains shall be the position Latitude. But if the inclination shall be Northward, then compare the elevation of the *Meridian* with your Latitude, and take the lesser out of the greater, so the difference shall be the position Latitude, as in this Example, supposing



ſuppoſing the inclination to be northward, I take 20 deg. 16 min. the elevation of the Meridian, out of 51 deg 32 m. the Latitude, and there remains 31 deg. 16 min. for the poſition Latitude, or the arch of the Meridian between the Pole and the Plain. This being done, ſet 31 deg, 16 min. from B to T, in the arch B C, and draw the line A T, then with the diſtance K L, upon the centre A, deſcribe the arch Y M W, cutting the line A T in M, through M, draw R S parallel to A B, cutting the arch B C in S, ſo ſhall B S be 30 deg. 20 min. the height of the Pole above the plain: Then lay your Ruler upon the point S, and the centre A, and where it ſhall cut the line K L, there make a mark as at *n*, and through *n* draw the line *D n n W*, cutting *Y W* in the point *n*, and the arth *B C* in *W*, ſo ſhall the arch *B W* be 7 deg. 51 min. the diſtance of the Subſtile from the Meridian. Laſtly, through the point *n*, draw Y X parallel to A C, ſo ſhall B X be 15 deg. 17 min. the inclination of Meridians.

CHAP. XIV. *SECT.* 1.

How to finde the neceſſary requiſites for all Verticall declining, and Meridian inclining Dials, in 7 ſeverall Latitudes, by the Diagonal Scales on the Ruler, and lines of Sines and Tangents joyning to the ſaid Scales, and being of the ſame Radius with them.

AND firſt, for Verticall declining Dials: The Latitude of the place, and the Declination of the plain being given, to finde the height of the Stile above the Subſtile.

Extend the Compaſſes from the beginning of the line of Sines, to the complement of the declination, and that ex-

extent will reach in the Diagonal *Scale* (known by the letters (*Stile Ver*) respecting the parallel proper for the Latitude) from the beginning thereof to the height of the Stile required.

Take the Example of the last Chapter, a plain declining 28 degrees in the Latitude of 51 degrees 32 minutes, the complement of 28 is 62, these 62 degrees take out of the line of Sines, and measure it in the Diagonal Scale (*Stile Ver*) setting one foot of the Compasses at the beginning thereof betwen the parallels of 51 and 52 (being the Latitude is 51 degrees 32 minutes) and extend the other foot upward, and let it rest between the same parallels, so you shall find it to reach to 33 degrees 20 minuts, for the height of the stile required.

Then secondly, to find the inclination of *Meridians*. If the declination of the plain be less then 45 degrees, take it out of the Scale of Tangents, and apply it to the diagonall Scale (*Incl Ver.*) in its proper parallel, and it will reach in the same Scale, and on or between like parallels to the inclination of *Meridians* required:

In the same Example { Latitude 51 degrees 32 minutes / Declinat. 28 00

Take 28 degrees out of the line of Tangents, and measure it in the Diagonall Scale (*Incl Vert*) between the parallels of 51 and 52, and it will reach to 34 degrees 32 minutes, for the Inclination of Meridians required:

But if the Declination of the plain exceed 45 degrees, then take the complement thereof out of the Diagonal (*Incl Vert*) in the proper parallel, and measure it in the Tangent, and it will reach to the complement of the Inclination of Meridians required.

As for Example,] A Plain in Latitude 51 degrees 32 minutes, declining 80 degrees: the complement of 80 is 10, take it out of the Diagonal, (*Incl Ver*) between the parallels of 51 and 52, and measure it in the Tangent line, and it will reach from the beginning to 7 degrees 52 minutes, the complement of the inclination of meridians required,

required; so the Inclination of meridians for that plain will be 82 degrees 8 minutes.

Then to finde the Requisites for Meridian Inclining Plains, the Latitude of the place And the Inclination of the Plaine being given, and first to finde the hight of the Stile above the Substile.

Extend the Compasses from the beginning of the line of Sines to the complement of the Inclination of the Plain, and that extent will reach in the Diagonall Scale (*Stile Mer*) and in the parallel proper for the Latitude, to the height of the Stile required.

Take the Example of the last Chapter, being of a Meridian plain in the Latitude of 51 degrees 32 minutes, Inclining 40 degrees. The complement of 40 is 50, take it out of the line of Sines, and measure it in the Diagonal Scale (*Stile Mer*) between the parallels of 51 and 52, and it will reach to 36 degrees 49 minutes, for the height of the Stile required.

Then secondly, to finde the Inclination of Meridians. Note that if the Inclination of the Plaine be lesse then 45 degrees you must take it out of the Tangent and apply it to the Diagonall Scale [*Incl Mer.*] in its proper parallel and it will reach in the same Scale to the Inclination of *Meridians* required.

As in the last mentioned Example of a Plaine in the Latitude of 51 deg 32 min. Inclining 40 deg. Take 40 degrees out of the Tangent and measure it in the Diagonal Scale [*Incl Mer.*] and it will reach to 53 deg. 26 min. for the *Inclination* of *Meridians* required.

But if the Inclination of the Plaine exceed 45 deg. then take the Complement thereof out of the Diagonall Scale [*Incl Mer.*] in the proper Parallel and measure it in the

Tangent, and it will reach to the Inclination of Meridians required.

Example. A Plain in the Latitude of 51 degrees 32 min. Inclining 50 degrees. The complement of 50 is 40, that take out of the Diagonal Scale (*Incl. Mer*) between the parallels of 51 and 52, and measure it in the Tangent, and it will reach to 27 degrees 35 minutes, the complement of the Inclination of meridians; so the Inclination of the meridians for that plain is 62 deg. 25 min.

SECT. 2.

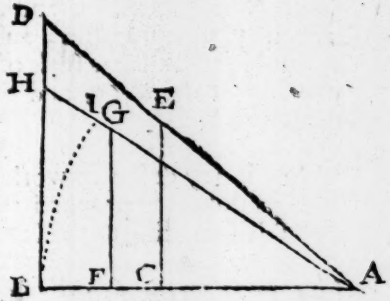
How to finde the necessary Requisites for all sorts of Dials, whether Vertical Decliners, Meridian Incliners, Polar Decliners, or Dials that both Decline and Incline or Recline, in any Latitude whatsoever.

NOw seeing that the Diagonal Scales mentioned in the former part of this Chapter, do give only the Requisites for Vertical Decliners, and Meridian Incliners, and that only in the Latitudes from 50 to 56 degrees, I have thought good to set down an easie way, how by the Sines and Tangents on the Ruler, to finde the Requisites for all sorts of Dials in any Latitude,

We wil in the first place make use of the first Example of this Chapter, *being a Diall in the Latitude of* 51 *deg.* 32 *min. Declining* 28 *degrees.*

By help of some square Instrument (for expedition sake) draw the Rectangle D B A, and make A B equall to the

the Radius (that is to say) the *Sine* of 90, or Tangent of 45 deg.) make B D equall to the cosine of declination 62, and draw A D, then make A C equal to the cosine of the latitude 38. 28, and draw C E parallel to B D, to cut A D in the point F, so C E being measured in the *Scale* of *Sines*, wil appear to be 33 degrees 20 minutes, the angle of the height of the stile above the substile, or the height of the Pole above the plain.



Again, make A F equal to the sine of the latitude 51.32 and F G equal to the tangent of declination 28, and draw A G, and prolong it to cut B D in the point H, so B H being measured in the scale of tangents, wil appear to be 34 degrees 12 minutes, for the angle of the Inclination of the *Meridians*.

Now in case you are to set off a tangent surmounting your scale (which goes but to 55 degrees) or if the Tangent B H had been greater then your *Scale* reacheth to, then you must open your compasses to the Radius of your scale, or 60 degrees of your fitted chord, and setting off that extent from B to A, draw the arch B I, and measure it in the same chord, and it wil give you the degrees answerable to the tangent line B H, be they more or less: This advertisement wil serve when ever you shal meet with the like case in the practice of the propositions that follow, for in what hath been already treated of, there was no need that the *Scale* of tangents should pass 45 degrees. Now

seeing the scale of chords reacheth but to 60 degrees, in case the arch you are to measure be more then 60, you must first set off 60, and take the residue of the arch in your compasses, and measure it from the beginning of the same scale of chords, and adde what you find it to be, to 60, and the sum is the value of the whole arch.

Now if any desire to work by the Canon, I have set down the proportion for each severall sort of Dial, relating to the scheme.

The Proportion for the Vertical Decliner.

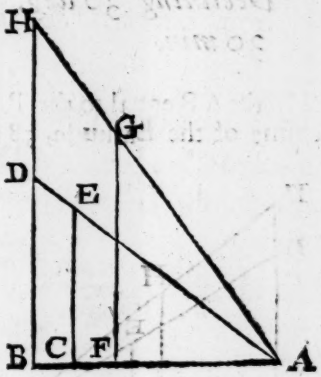
I. As A B Radius,
Is to D B the co-sine of the Declination, 62 deg.
So is A C, the Co-sine of the Latitude 38 de. 28m.
To C E, the Sine of the height of the Stile above the Sub-stile, 33 deg. 20 min.

II. As A F, the Sine of the Latitude, 51 deg. 32 min.
Is to the Radius A B;
So is F G, the Tangent of Declination, 28 deg.
To B H, the Tangent of the Inclination of Meridians, 34 deg. 12 min.

Then in the second place, for Meridian Inclining Dials, we will take the second Example of the first Section *of this* Chapter, *being a Plain in the Latitude of* 51 *deg.* 32 *min. Inclining* 40 *degrees.*

First, make A B equal to the Radius, and B D, equal to the Cosine of Inclination 50 deg. and draw A D. Again, make

make A C equal to the ſine of the latitude 51. 32, and draw C E parallel to B D, to cut D A in E, ſo ſhall C E meaſured in the ſcale of ſines, be 36 degrees 49 min: the angle of the height of the ſtile.



Again, make A F equal to the coſine of the latitude, 38. 28, and draw F G parallel to B D, and equal to the tangent of the plains Inclination, then draw A G at length, to cut B D prolonged in the point H, ſo ſhall B H, being meaſured in the ſcale of Tangents, be 51 deg. 26 minutes, for the angle of the Inclination of meridians.

The proportion for the Meridian Incliner.

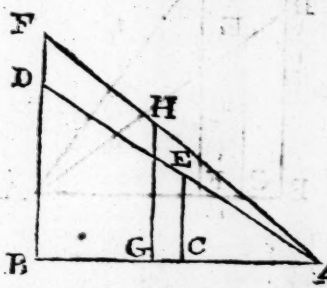
I. As A B Radius,
Is to B D, the co-ſine of inclination, 50 deg.
So is A C the Sine of the Latitude, 51 deg. 32 m.
To C E, the Sine of the Stiles height above the Sub ſtile, 36deg. 49 min.

II. As A F, the co-ſine of the Latitude 38. 28.
Is to A B Radius,
So is F G, the Tangent of the plains inclination, 40 degrees,
To B H, the Tangent of the Inclination of Meridians 53deg. 26 min.

The

The third sort of Plain shall be a Polar declining Plain, in the Latitude of 51 *deg.* 32 *min. Declining* 30 *deg. and Inclining* 34 *deg.* 30 *min.*

Make A B equal to the Radius, and B D equal to the cosine of the Latitude, 38 degrees 28 minutes, and draw A D, then make A C equal to the sine of the declination, 30 degrees, and draw C E parallel to B D, to cut A D in the point E, so C E being measured in the Scale of Sines, will appear to be 18 degrees 7 minutes, whose complement 71 degrees 53 min. is the arch between the Horizon and the substile.



Again, make B F equal to the sine of the Latitude, 51: 32, and draw A F, then make A G equal to the Tangent of the declination 30 deg. and from G, draw G H parallel to B D, to cut A F prolonged in H, so G H being measured in the Scale of Tangents, will be 24 deg. 19 min. the angle of the Inclination of the meridians.

The proportion for the Polar Decliner.

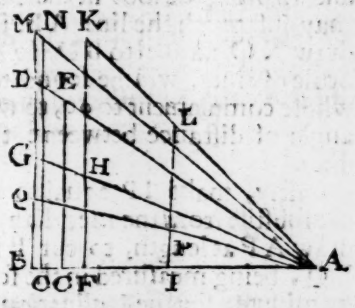
I. As A B, Radius,
Is to B D, co-sine of the Latitude, 38. 28.
So is A C, the Sine of the Declination, 30 deg.
To C E, the Sine of 18 deg. 7 min. whose complement to 90, to wit, 71 deg. 53 min. is the quantity of the arch between the Horizon and the Substile.

II. As

II. As A B Radius,
To B F the Sine of the Latitude, 51 deg. 32 m.
So is A G, the Tangent of Declination 30 deg,
To G H the Inclination of Meridians, 24 deg, 19 min,

The Fourth and last sort of Plain shall be a Declining Inclining Plain, in the Latitude of 51 deg. 32 min. Declining 34 deg. and Inclining 24 deg. Being the Plain mentioned in the 13th. Chapter, *and being the third* Example *in that* Chapter.

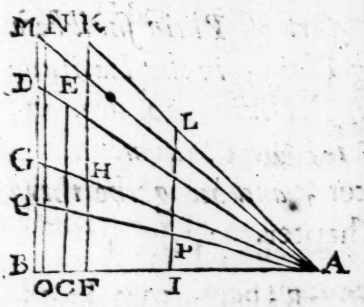
First, make A B equal to the Radius, and B D equal to the Tangent of Declination 34 degrees, and draw A D then make A C equal to the cosine of the Inclination, 66 degrees, and draw C E parallel to B D, to cut A D in the point E, so shall C E, being measured in the scale of Tangents, be 31 degrees 38 minutes, whose complement to 90 is 58 degrees 22 minutes, the angle between the Horizon and Meridian,



Secondly, make A F equal to the Sine of the meridians altitude 58 deg. 22 min. & B G equal to the Sine of the Plains Inclination, 24 degrees and draw A G, then draw F H parallel to D B, to cut A G in H, so shall F H being measured in the Scale of Sines, appear to be 20 deg. 16 minutes, which being subtracted out of the Latitude, 51 de-

51 degrees 32 minutes, there will remain 31 degrees 16 minutes, for the Position latitude, or the arch of the meridian between the Pole and the Plain.

Thirdly, make A I equal to the sine of the Position Latitude 31 degrees 16 minutes, and prolong F H to K, and make F K equal to the cosine of the declination 56 de. and draw A K, and from the Point I draw I L parallel to B D, to cut A K in the point L, so I L being measured in the Scale of Sines, wil appear to be 30 degrees 22 minutes, the height of the stile.



Fourthly, prolong B D to M, and make B M equal to the cosine of the stiles height, 59 deg. 38 min. and draw A M, then take in your compasses the cosine of the position Latitude 31 degrees 16 minutes, to wit, 58. 44, and so place one foot in the line A M, as that the other may just touch the line A B, there make a mark as at N, draw N O parallel to B D, so A O being measured in the Scale of Sines, will be found to be 82 degrees 9 minutes, whose complement to 90, to wit, 7 degrees 51 min, is the angle of distance betweene the Substile and the Meridian.

Lastly, make I P equal to the sine of the distance of the substile from the meridian, 7 degrees 51 minutes, and draw A P at length, to cut B D in the point Q, so shall B Q, being measured in the scale of Sines, be 15 degrees 17 minutes, for the Inclination of the Meridians.

The

The Proportion for the Declining Inclining Dial.

I. As A B Radius,
Is to B D, the Tangent of Declination, 34 deg.
So is A C the co-sine of Inclination 66 deg.
To C E, the Tangent of 31 deg. 38 min. whose complement to 90, to wit, 58 deg. 22 min. is the angle between the Meridian and Horizon.

II. As the Radius, A B,
Is to A F, the Sine of the angle between the Meridian and horizon 58 deg. 22 m.
So is B G, the sine of Inclination 24 deg.
To F H, the Sine of 20 deg. 16 m. which being taken from the Latitude 51 de. 32 m. there remaines 31 deg. 16 min. for the position Latitude.

III. As A F the Sine of the angle between the Meridian and horizon. 58 deg. 22 m.
Is to A I, the sine of the position Latitude 31 d. 16 m
So is F K, the Co-sine of declination. 56 deg.
To I L, the height of the Stile above the Substile, 30 deg. 22 minutes.

IV. As B M, the Co-sine of the Stiles height 59 d. 38 m.
Is to A B Radius,
So is O N, the cosine of the position Lati. 58 d. 44 m.
To A O, the sine of 82 deg. 9 min. Whose complement to 90. to wit, 7 deg. 51 min. is the distance between the Substile and Meridian.

V. As A I, the Sine of the position Latitude 31. 16.
Is to I P, the Sine of the distance between the substile and Meridian, 7 deg. 51 min.
So is A B, Radius,
To B Q the Inclination of Meridians 15 deg. 17. m.

CHAP. XV.

How to draw the Hours on an erect Verticall Declining Plain.

HAving, either by the 13 th, or 14 th. Chapters, obtained those necessary requisites there mentioned, you may proceed to draw the houre lines on all those Plains treated of in those Chapters, by the first Scale of Hours, as also all Polar declining Dials, and all far Declining Verticals by the Polar Scales.

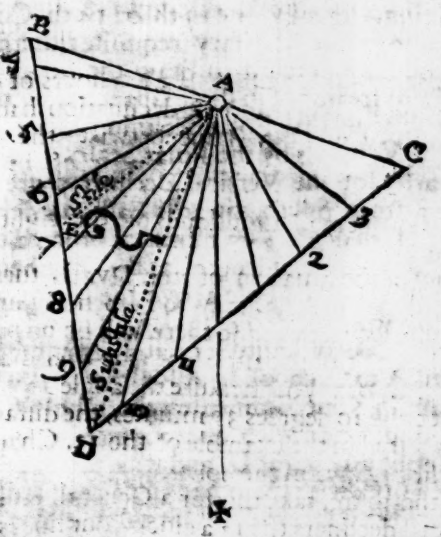
And first, for the Vertical Decliner there mentioned, declining from South towards East, 28 degrees, in the Latitude of 51 degrees 32 minutes, proceed thus.

First, draw a line at length, as B A C, then considering that the height of the Pole above the Plain, or the height of the Stile was found to be 33 deg. 20 m. take 33 d. 20 min. out of the Scale of Latitudes, and set it off from A to B, and from A to C, choosing A for the centre of the Dial. Then take in your Compasses the whole first Scale, or Scale of Hours, and with one foot fixed in B, with the other describe an arch at D, and with the same extent, one foot fixed in C, with the other cross that arch at D, and draw the lines B D and C D, as also the line A D for the substile. Then having found the Inclination of Meridians to be 34 deg. 12 min. seeke that in the second Scale, known by the letters (*Incl.*) and just against it on the first Scale you shall finde 2 houres 17 minutes. take off 2 hours 17 min. from that Scale, and set it from D to 12, and from B to 6,

Then extend your Compasses from the beginning of the same Scale to 00 hours 17 min. and set that from D to 10, and from B to 4. Then open your Compasses to 1 houre 17 minutes, of the same Scale, and set it from D

to

to 11, and from B to 5. Then open the compasses to 3 hours 17 minutes, and set it from D to 1, and from B to 7. Then open the Compasses to 4 hours 17 minutes, and set it from D to 2, and from B to 8. Then lastly, open your Compasses to 5 hours 17 minutes, and set it from D to 3, and from B to 9,



Now if you draw lines from A to these points, they shall be the hours proper for this plain, and no houre-lines are to be drawn beyond the line B C. Now if you please, you may set off the largest extents first, as 5 hours 17 min. and so go on, closing of the Compasses, til you come to 00 hours 17 min. for D 10, and B 4. See the Table following, whose first column contains the houres and minutes that are to be taken in your Compasses off of the first Scale, and set from D or B, to their respective houres on the Plain, contained in the second and third columns of the Table.

H	*M*	*frõ D tow C*		and	*frõ B tow D*	
5	17	D	3		B	9
4	17	D	2		B	8
3	17	D	1		B	7
2	17	D	12	*And*	B	6
1	17	D	11		B	5
0	17	D	10		B	4

Consider also, that the Inclination of Meridians being 34 deg. 12 min. or 2 hours 17 min. of time, and the declination toward East, the substile falls between the hours of 9 and 10 in the morning, whereas if the declination had been West, the Substile would have falne betwixt the houres of 2 and 3 in the afternoon, and the hour of 12. would have been towards the left hand of the substile, whereas the declination being East it stands on the right hand of the Substile

Now for the situation of the Dyall, turne the Paper about, so as that A 12. may be Perpendicular to the horizon and it sufficeth and so there will be no need of finding the distance of the Substile from the *Meridian*: for if with a line of Chords you measure the angle 12 A D, you shall finde it to be 20 degrees 30 minutes, the distance required, as was found in the example of the 13. Chapter relateing to the first Diagram thereof.

Furthermore, take this for a Generall Rule, that in all Verticall decliners the 12 a clock hour line is Perpendicular to the horizontal line of the Plaine, and in Meridian Inclineing Plaines the 12 a Clock Hour-line is parallel to the Horizontall line of the Plaine, so that for Dialls of these two kindes you are not necessitated to finde the angle of distance of the Substile from the Meridian.

Note also, if you Ogle the Pattern of this Diall drawn in paper, it will serve for 3 other Dials that have the same Declination.

First, a Diall for the Southwest face of the Plain, if you change the side, and the numbers set to the hours the Centre

Centre of the Diall being upwards and the ſtile and Subſtile pointing downwards.

Secondly, a Diall for the North-Weſt face, if you turne the pattern upſide down, and changeing the ſide, takeing the backſide for the foreſide, not altering the houres, the ſtile and Subſtile pointing upwards,

Laſtly, a Diall for the North-Eaſt face, if you take the foreſide, onely turning it upſide down, and altering the numbers ſet to the hours, the Stile and Subſtile pointing upwards.

To conclude, the Stile for this Diall muſt be elevated 33 deg. 20 min. as the angle E A D, and the Diall is finiſhed.

I have been more large in this Chapter then I ſhall be in what ſhall follow, touching all other Dialls with Centres by reaſon the drawing and ſetting off the houres is the ſame with the worke of this Chapter.

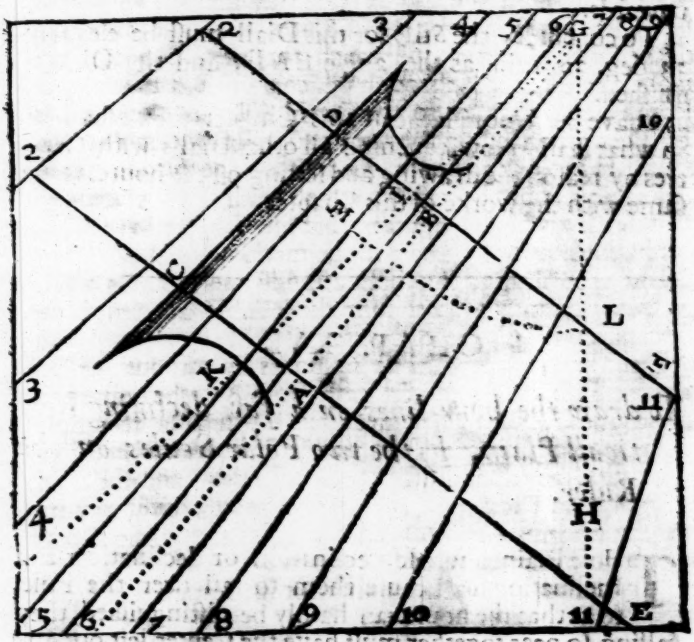
CHAP. XVI.

To draw the hour-lines on a far declining Verticall Plain, by the two Polar Scales on the Ruler.

THoſe Plaines whoſe declination or declination and Inclination ſhall cauſe them to fall neer the Pole, ſo as that the houres can hardly be diſtinguiſhed, they falling ſo neer together muſt have the Center left out, and the ſtile increaſed, and then the hours may be eaſily, and ſpeedily drawn by the directions following.

Theo-

The Example ſhall be of a Vertical Plain declining Eaſt from South, 80 deg. By the directions of the 13 th. or 14 th. Chapters, you ſhall finde the Inclination of Meridians to be 82 deg. 8 min. and the height of the Pole above the Plain 6 deg. 12 min. and, if you pleaſe, you may finde the diſtance of the ſubſtile from the Meridian by the 13 th. Chapter, which in this Example wil be found to be 38 deg. 5 min.



Proceed thus, Draw firſt the perpendicular G H, then with the Radius of your line of Chords, deſcribe the arch L M, and ſet off the Stile and ſubſtile with the ſame line of Chords, according to their reſpective angles, and draw the pricked lines G B A for the ſubſtile, and G I K for the ſtile.

Then

Then choose any point in the substile, as A, through which point A, draw a line at length, making right angles therewith, as the line H A C, that done, fix one foot of your Compasses at the beginning of your longer Polar Scale, and extend the other to the houre of 3, set off this extent from A to C, and through the point C draw a line parallel to the stile G I K, as the line C D, so shall C D be the stile increased. Then open your Compasses from the beginning of your second or lesser Polar Scale, to 3 hours, and with that extent, place one foot of the Compasses in the substile A B C, carrying it along the said line, until the other foot of the Compasses may just touch the line C D, and there make a mark as at B, through which point B, draw a line at length, and parallel to the line H A C, as the line D B E. Then considering the Inclination of Meridians was found to be 82 deg. 8 min. finde it on the second Scale, and against it on the first Scale you shall finde 5 hours 29 minutes, by which it appears that the substile falleth between the hours of 6 and 7 in the morning.

Now according to the Inclination of meridians, 5 hours 29 min. you may proceed to make a Table, and set off the hours accordingly, as followeth,

Open your Compasses to 00 hours 29 minutes, of the greater Polar Scale, and set it off from A to the hour of 7, in the line C A E. Then open the Compasses to 1 hour 29 minutes of the same scale, and set it from A to 8. Then open the Compasses to 2 hours 29 minutes, and set it off from A to 9. Then open the compasses to 3 hours 29 min. and set it from A to 10. Lastly, open the compasses to 4 hour, 29 minutes, and set it from A to 11.

Now having found the points for the hours on one side of the substile from A towards E, you must do the like for the other side of the substile: and considering that the first houre from the substile towards E, namely A 7, contains the distance of 00 h. 29 m; as by the following Table appears the complement thereof to 60 min. or one hour, is 60 hours 31 minutes, as by the said Table appears.

Pro-

From A towards E			*From A towards C.*		
H	*M*	*ho. on the Pl.*	*H*	*M*	*ho. on the Pl.*
0	29	*A* 7	0	31	*A* 6
1	29	*A* 8	1	31	*A* 5
2	29	*A* 9	2	31	*A* 4
3	29	*A* 10	3	31	*A* 3
4	29	*A* 11	4	31	*A* 2

Proceed to set off 00 hours 31 minutes taken from the same Polar Scale from A to the hour of 6, and the extent of the Compasses to 1 houre 31 min. set from A to 5, also 2 hours 31 min. set from A to 4, and 3 hours 31 min. from A to 3: and lastly, the extent of the compasses from the beginning of the Scale to 4 hours 31 min. set off from A to 2, and so you have points for all the hours of the plain on the line C A H.

Now for the other line D B F, you must set off the hours thereon (taken out of the lesser Polar scale) from B both ways according to the Table, in all respects as you did set off the hours from A. This being done draw lines through the respective points found in the lines C A H, and D B F, and those lines shall be the hour lines for the Diall.

The *Stile* must be a thin Plate to stand directly over the *Substile*, as in the Figure is demonstrated by A B and C D.

CHAP. XVII.

To draw the Hours on a Meridian Inclining Plain.

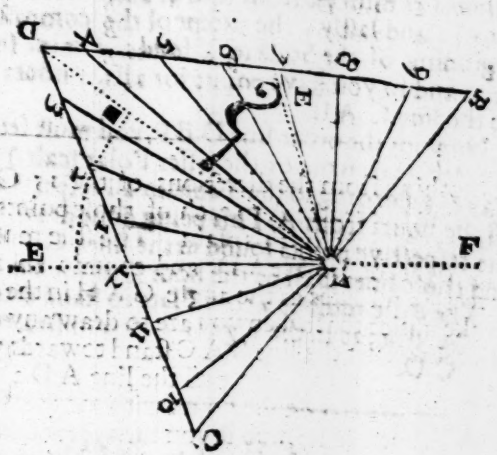
THose Plains whose Horizontal line is the same with the *Meridian* line, are called *Meridian* Plains, as the di-

direct East and West. But if they lean to the Horizon they are called Incliners.

Those Plains may Incline either to the East or West part of the Horizon, and each of them hath two faces, the upper towards the Zenith, the lower towards the Nadir.

Take the Example of the 13 th. or 14 th. Chapters, of a Meridian Inclining plain in the Latitude of 51 deg 32 m. whose Inclination to the Horizon is 40 deg.

Having, by the former instructions, found the height of the Pole above the Plain to be 36 deg. 49 min. the Inclination of the Meridians 53 deg. 26 m. (and, if you pleas, the distance of the substile from the Meridian, 38 degrees 57 min.) you may proceed to make the Diall thus.



Draw the Horizontal line E A F, and make A the centre of the Dial, Then with the Radius of the line of Chords, draw the arch E G H, & set off the distance of the Substile from the Meridian from E to G, and from the centre A, draw A G D for the Substile.

Again, through the centre A, draw B C at right angles to the ſubſtile A D. Then make A B and A C equal to the height of the ſtile taken out of the line of Latitudes, 36 deg. 49 min. finde then the Inclination of Meridians on the ſecond Scale, which is 53 deg. 26 min. and againſt it on the firſt Scale you ſhall finde 3 hours, 34 min. which being taken out of the ſame ſcale, and ſet from D and B, gives points for the hours of 12 and 6, the reſt of the work differs nothing from the directions of the 15 Chap. Draw lines from the centre A to each of thoſe points, and they ſhall be the hours for this plain. The ſtile muſt ſtand directly over the ſubſtile A D, and contain an angle of 36 degrees 49 minutes, as the angle G A H in the diagram.

From D towards C				*From B towards D.*	
H	*M*	*Hou. Plai*		*Hours on the Plain*	
0	34	D	3	B	9
1	34	D	2	B	8
2	34	D	1	B	7
3	34	D	12 *And*	B	6
4	34	D	11	B	5
5	34	D	10	B	4

Take notice that when you are to draw any of the Dials with centres, let the line B A C ſtand towards you, as if it were the Horizontal line, and the line A D a plumb-line, and ſo you will ſet off the hours with more eaſe, as in the direct Vertical dial; and if you turn the Paper ſo as that the hour of 12 may be parallel to the Horizon, you need not (as in the laſt Chapter was declared) find the angle of the diſtance of the ſubſtile from the Meridian.

Note that this example being a Meridian Plain Inclining Eaſt, the ſubſtile muſt ſtand towards the left hand of the Meridian line or hour line of 12.

CHAP.

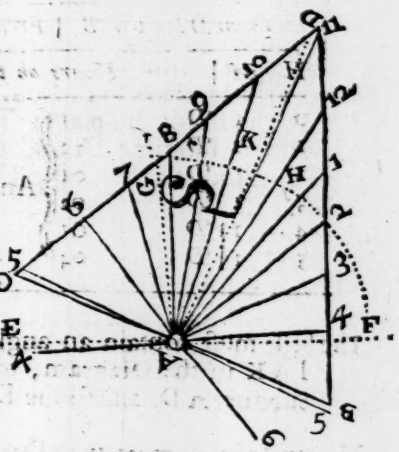
CHAP. XVIII.

To draw the Hour-lines on a Declining Inclining Plain.

A Plain that declines from the Prime Vertical and Inclines to the Horizon, and yet lyeth not even with the Poles of the world, is called a declining inclining Plain.

Of these there are severall sorts, for the Inclination being northward, the plain may fall between the Horizon and the Pole, or between the Zenith and the Pole,

Or, the Inclination may be Southward, and may fall either below the intersection of the Meridian and the Equator, or above it: and each of these have two faces, the upper towards the Zenith, and the lower towards the Nadir.



Take the Example of the 13 th. Chapter, according to the 3 d. Diagram of that Ch.) being a Plain that declineth from the south towards the East 34 d. and inclineth to the Horizon 24 deg. in the Latitude of 51 deg. 32 min. the height of the Pole above the plain was found to be 30 d 20 m. the arch of the plain from the Horizon to the Meridian, 58 deg. 22 min. the Inclination of Meridians 15 deg. 17 min. and the distance of the substile from the meridian 7 deg. 51 min. This is

all we need to know before we begin to make the Dial, which is effected after this manner.

Draw first the Horizontal line E F. Then with the Radius of your line of Chords, draw the arch F K, set off the altitude of the meridian 58 deg. 22 min. from F to H, and the distance of the Substile from the meridian 7 deg. 51 m. from H to K, and let A be the centre of the Dial, then draw the line A K D for the Substile, and B A C at right angles thereto, make A B and A C equal to the height of the Pole above the Plain 30. deg. 20 min. taken out of the scale of Latitudes, then set off the whole first Scale or hour scale, from B and C to D, as hath been before shewn. Then considering the Inclination of *Meridian*, was found to be 15 deg. 17 min. finde it on the second Scale, and against it on the first Scale you shall finde 1 houre 1 min. so proceed to set off the hours as hath been formerly taught, and as this following Table demonstrateth.

From D towards B			*From C towards D*		
H	*M*	*Hours on the Plain.*			
0	1	D 11	And	C	05
1	1	D 12		C	06
2	1	D 01		C	07
3	1	D 02		C	08
4	1	D 03		C	09
5	1	D 04		C	10

The Stile must contain an angle of 30 deg. 20 min. as I A K in the Diagram, to stand directly over the Substile, A D, and so the Diall is finished.

Now when you meet with Declining Inclining Plains, you must consider which Pole is elevated above your plain,

plain, and how to place the meridiaa from the horizontal line: For,

Upon the upper faces of all North Incliners, whose meridians elevation is lesse than the Latitude of the place: On the under faces of all North Incliners, whose meridians elevation is greater then the Latitude of the place: And on the upper faces of all South Incliners, the North Pole is elevated,

And upon the under faces of all North Incliners, whose elevation is lesse then the Latitude of the place: On the upper faces of all North Incliners, whose meridians elevation is greater than the Latitude of the place: And on the under faces of all South Incliners, the South Pole is elevated.

Now for placeing the *Meridian* from the Horizontal line: Upon the upper faces of all South Incliners, whose meridians elevation is greater than the complement of the Latitude: On the under faces of all South Incliners, whose meridians elevation is lesse than the Latitudes complement: On the under faces of all North Incliners, whose meridians elevation is greater then the Latitude of the place: And on the upper faces of all North Incliners, whose meridians elevation is lesse than the Latitude of the place: The *Meridian* must be placed above the Horizontal line: as in our Example.

Again contrariwise, For the upper faces of all South Incliners, whose meridians elevation is lesse than the complement of the Latitude: On the under faces of all South Incliners, whose meridians elevation is greater than the complement of the Latitude: On the under faces of all North Incliners, whose meridians elevation is lesse than the Latitude of the place: And on the upper faces of all North Incliners, whose meridians elevation is greater than the Latitude of the place: The *Meridian* must be placed below the Horizontal line.

But if it be either the upper or under faces of a South Inclining plain, whose meridians elevation is greater then the Latitudes complement. : Or either the upper or under faces of a North inclining plain, whose meridians elevation is lesse then the Latitude of the place, that then the meridian must be placed from that end of the Horizontal line with the declination of the plain.

But on all the other Faces of these kiads of plains, the meridian must be placed from that end of the Horizontal line, which is contrary to the Declination of the plain.

Note also, that if the inclination be Southward, and the elevation of the meridian equal to the complement of your Latitude, then shall the substile lie square to the meridian.

CHAP. XIX.

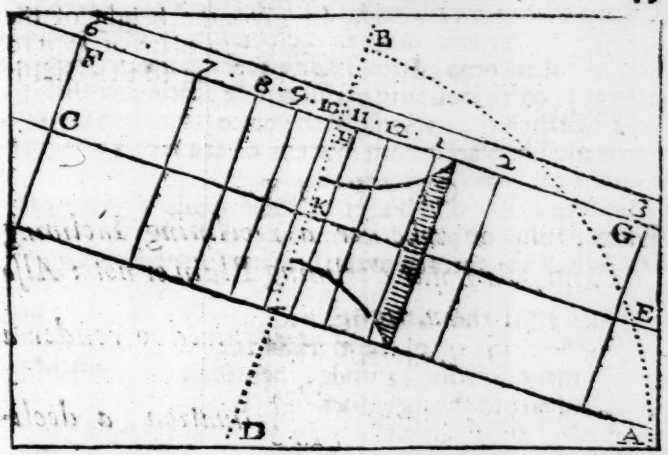
To make a Diall on a Polar Declining Plain.

THese plains, if the Inclination be Northward, and the elevation of the meridian equal to the Latitude of the place, then neither Pole is elevated above the plain, and therefore it is a Declining Polar

Example, A Plain in the Latitude of 51 deg. 32 min. declining East from South 30 deg. and inclining North 34 degrees 30 min.

Draw first the Horizontal line D A, then with the Radius of your line of Chords, describe the arch A B, and by the rules of the 13 th. Chap. you shall finde the distance of the horizon and meridian to be 71 deg. 53 min. which set off from A to B, in the arch A B, and draw B D for the substile. Then at right angles to the Substile draw the lines F G and C E, and having found the inclination of meridians to be 24 deg. 19 min. finde it on the second Scale, and against it on the first Scale you shall find 1 hour 37 min.

Then



Then having recourſe to the Table following, ſet off the hours from K and H, according to the directions of the 16. Chap. for the far decliner, taking the ſeveral diſtances with your Compaſſes out of either of the Polar Scales, & ſetting them off from K towards C and E, as the Table plainly ſheweth, drawing lines parallel to the Subſtile through thoſe points, and thoſe lines ſhall be the houre-lines required for that plain.

From K towards E			*From K towards C.*		
H	*M*	*ho. on the Pl.*	*H*	*M*	*ho. on the Pl.*
0	37 K	11	0	23 K	10
1	37 K	12	1	23 K	9
2	37 K	1	2	23 K	8
3	37 K	2	3	23 K	7
4	37 K	3	4	23 K	6

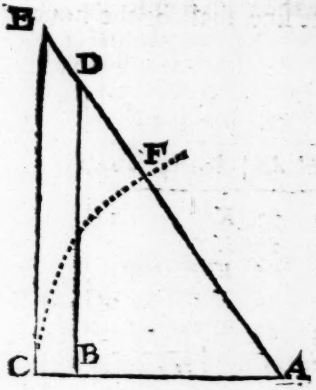
The extent of the Compaſſes from the beginning of the ſame.

same polar scale to the hour of 3, gives the height of the stile above the substile, which may be a plate of Iron ro Brass set up just over the substile H K; and so the Dial is finished.

CHAP. XX.

How to know whether a Declining Inclining Plain, be a Polar declining Plain or not: Also wh at {Inclination / Declination} is required to render a Plain in a given {De / In}clination a declining Polar.

Suppose the Latitude to be 51. 32, the declination 30, and the inclination 55. 28, make *A C* equal to the radius, C E equal to the tangent of the inclination, and draw A E; again, make A B equal to the co-sine of declination, and draw D B parallel to C E; so B D being measured in the tangent scale, if it appear to be the tangent of the Latitude, then is that plain a polar plain, otherwise not.



2ly. To a given declination to find what inclination is required to make the plain a declining polar. *M*ake AC equal to the radius, A B equal to the cosine of the declination, and B D equal to the tangent

gent of the Latitude, and draw A D, and prolong it, then draw C E parallel to B D, and measure it in the Scale of Tangents, and it wil shew the inclination to be 55 d. 48 m.

Thirdly, To a given Inclination to finde what declination is required to make it a Polar declining plain. Make A C equal to the Radius as before; C E equal to the tangent of the inclination, and draw A E: then open the Compasses in the Tangent Scale to the tangent of the Latitude, and so place one foot in the line A E, as that the other may just touch the line A C, there make a mark as at D, draw D B parallel to C E, so A B being measured in the scale of Sines wil give the co-sine of the declination 60, so the declination required is 30 deg.

Note, that if the inclination be so great as to pass beyond the tangent Scale, you may help your self, as by the instructions after the first Exam. of the 2. Sect. of 14 Ch. by drawing the arch C F, and seting off the Inclination (taken out of the scale of Chords with which you drew that arch) to wit, that of the same Radius with the *Sines*, *Secants* and *Tangents*) from C to F: this only happens when the Latitude and Declination a revery great.

Otherwise, (having respect to the former Scheme) you may make A C (as there) Radius, A B cosine of declination, and C E cotangent of Latitude, then wil B D be the cotangent of the Inclination, this is sufficient directions for finding all this Chapter speakes of, be the Latitude, declination, or inclination, great or small.

The Proportions for these Three Cases.

I. As A C Radius,
Is to A B the cosine of Declination 60 deg.
So is C E the Tangent of Inclination 55 deg. 28 m.
To B D, the Tangent of 51 deg. 32 min. *Which being the Latitude, shews the plain to be a Polar plain.*

II. As A C Radius,
Is to A B the cosine of Declination 60 deg.
So is B D the Tangent of the Latitude 51 deg. 32 m.
To C E the Tangent of Inclination,
To render the plain polar 55 deg. 28 min.

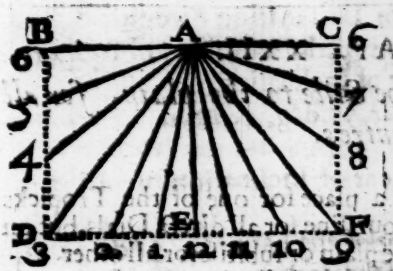
III. As C E the Tangent of Inclination, 55 d. 28 m.
Is to A C Radius,
So is B D the Tangent of the Latitude, 51 d. 32 m.
To A B the co-sine of the declination 60 deg.
So 30 is *the declination requisite,*
To make the plain a polar plain.

CHAP. XXI.

To draw an Horizontal or Vertical Dial, otherwise then hath been before taught, (to wit) By a particular Diagonal Scale framed for that purpose.

DRaw a line of any convenient length, as the line D E F, and about the middle thereof, as at E, erect a perpendicular, as E A, make B A equal to the Radius or Tangent of 45 deg. and let A be the centre of the Dial, and A E the meridian or houre of 12. Then having recourse to your Diagonal scale, known by the letters (*Horiz.*) at the beginning, take with your Compasses one of the parallel proper for the Latitude three hours, and with that extent, placeing one foot in E, extend the other on both sides to D and F. as also from A both wayes to B and C, and draw the Rectangled Parallelogram B C D F.

Then



Then extend the Compasses from the beginning of the same parallel to 2 hours, and set off that extent both wayes from E to 2 and 10: again, extend the compasses from the beginning of the same parallel to 1 hour, and set off that extent from E, to 1 and 11. Then extend your Compasses from the beginning of your Tangent to 30 deg. and place that from B to 4, and from C to 8; again, take out of the same Scale 15 deg. and place that extent of the Compasses, from B to 5, and from C to 7. Then draw lines from the centre A, to all those points, and they shall be the Houre-lines required, A B and A C being the two houre-lines of 6.

Lastly, draw through the centre the houre-lines of 7 & 8 in the evening, and 4 & 5 in the morning, and you have all the houres for the Horizontal Dial.

The worke is the same for the Vertical, only you must have recourse to the parallel proper for the complement of the Latitude, and change the hours on each side of the meridian A E, the one for the other: that is to say, if you were to draw a Vertical Dial in the Latitude of 56 degrees, you must work on the parallel of 34. and then for numbering the hours, whereas in the Horizontal Dial, the hours for the morning (to wit, the hours of 8, 9, 10, 11, 12, 1, 2, 3, 4,) were placed on the right hand of the meridian, in the Vertical they must be placed on the left.

Note, the Example in this Chapter is of an Horizontal Dial in the Latitude of 51 deg. 32 min.

CHAP.

CHAP. XXII.

How to proportion the Stile to the plain, for all Dials having Centres.

FIrst, make choise of a place for one of the Tropicks on the 12 a clock hour line for all direct Dials, but on the meridian of the plain or substile for all other.

2. Consider the height of the Stile above the Plain, and to it adde 66. 29, if the place assigned be for the Tropick nearest to the centre of the Dial, and 113. 31, if for the Tropick most remote therefrom, and the complement thereof to 180 shall be the Suns altitude above the plain, when he comes to that Tropick.

An example shall be the Vertical decliner of the 15 th. Chap. whose stiles height is 33. 20, to which I adde 113. 31, for the remotest Tropick, to wit, that of *Cancer*, and the summe is, 146 deg. 51 min. whose complement to 180 deg. is 33 deg. 9 min. which note. Now the distance between the centre and place assigned we wil estimate any number of equal parts, suppose 100. Then use this proportion.

As A B the Sine of 113. 31. Or 66. 29, which is all one,
Is to A C, the Sine of 33. 9.
So is B D. 100,
To C D 60, for the length of the Axis.

And supposing the Stile to be a thin triangular plate, the dimensions of the other sides may be found, the length of the Axis being given, as suppose 60. Say,

As A B Radius,
Is to A C, the Sine of 33. 20,
So is B D 60, the length of the Axis,
To C E 33, the length of the perpendicular,

And (

And Lastly.

As A B Radius,
Is to A C the cosine of 33. 20, to wit, the Sine of 56. 40,
So is B D 60,
To C E 50, for the length of the Substilar side of the Stile.

But if you would proportion the Stile to the plain, so as to cast the shadow at the ful length all the year: then consider the Sun in the Tropick neerest the centre, and adde 66 deg. 29 min. to the height of the stile 33 deg. 30 min. makes 99 deg. 49 min. the complement is 80 deg. 11 min. Say.

As A C, the Sine of 66. 29,
Is to A B the Sine of 80. 11,
So is C E, any number of equal parts, suppose 100, the length on the Substilar (from the centre to the border of the hours),
To B D, 107 of the same parts, the length of the Axis.

I shall conclude this small Treatise with some brief and easie instructions (deducted from that ingenious invention of Mr. Halton, *mentioned in his Letter to his friend printed at the end of Mr.* Fosters *Miscellanies) shewing how to draw the hour-lines on any Cieling, whether plain or irregular reflected from a small piece of Glasse placed in some part of the Transom of a Window, whether it lye parallel to the Horizon, or oblique thereunto, as also, how to find the exact situation of the Glass, wherein I have endeavoured to make the things plain to the meanest capacity.*

OF Reflex Dialling.

CHAP. XXIII.

How to finde the Pole or perpendicular of the Glasse, and consequently the Plain thereof, in respect of Declination and Reclination.

Supposing a piece of Looking-glasse, of about a quarter of an Inch diameter, to be fixed in some part of the Transom of any Window (either in a Socket made on purpose (which is best) or let into the transome) at any convenient obliquity: Before you proceed to draw the Houre-lines, it will be requisite (according to the method I shall set down) to finde the Pole or perpendicular of the Glasse, to effect which, observe the following precepts. which will effect the worke severall wayes.

First, Geometrically, by Scale and Compasse, protracting the worke upon paper.

Secondly, By Trigonometrie.

Thirdly, By Projecting of the Sphere in *Plano*.

1 The

1 The Sun shining on the Glasse, observe in what part of the Wall or Cieling the spot of the reflexion appeareth, and there make a mark: take also the altitude of the Sun as neer as you may to that very instant.

2 Having the Suns altitude finde its Azimuth from the South, by the instructions of the third Chapter.

3 Take the altitude and Azimuth of the reflected spot, the altitude is thus found: Extend a string from the centre of the Glasse to the spot of Reflection, and thereunto apply a Quadrant, whose thrid will cut the limb thereof in the altitude required, to be accounted always from that side of the Quadrant that is farthest off from the window.

The Azimuth of the reflected spot is thus found,

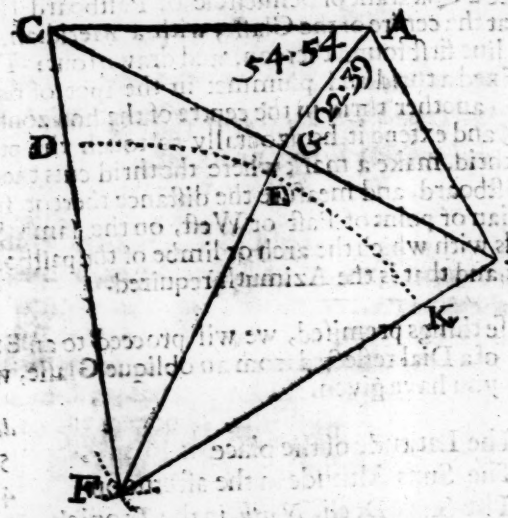
Place a Quadrant or Semicircle of Pastboard Horizontally, at the centre of the Glasse, with a *Meridian*, East or West line first found thereon, and drawn out: Then having fixed a thrid and plummet in the spot of reflexion, fix also another thrid in the centre of the horizontal Pastboard, and extend it horizontally to touch the perpendicular thrid, make a mark where the thrid cuts the limb of the Pastboard, and measure the distance thereof from the meridian or point of East or West, on the same Scale of Chords with which the arch or limbe of the pastboard was drawn, and that is the Azimuth required.

These things premised, we will proceed to an Example of a Dial reflected from an oblique Glasse, wherein you have given.

		deg.	*min.*
1	The Latitude of the place	51	32
2	The Suns Altitude in the afternoon	47	51
3	The Suns Decli. *North*, in the Tropick	23	31
4	The Suns Azimuth Westerly from South	60	12
5	The Altitude of the spot of Reflection	52	44
6	Its Azimuth from the Meridian towards East	4	12

To

To finde the Pole of the Glasse, consider the quantity of the angle made between the Suns Azimuth, and the Azimuth of the reflected spot: as thus, the Suns Azimuth South Westerly being 64 deg. 14 min. the complement thereof to the West point is 25 deg. 46 min. to which add the Azimuth of the reflected spot from West, to wit 94 deg. 11 min. makes together 119 deg. 57 min. Protract this angle on paper, as here you see done, by the lines A B and A C, the angle B A C being 119 deg. 57 min. make A C equal to the tangent of 42 degrees 9 minutes, the Complement of the Suns Altitude, and A B equal to the Tangent of 37 deg. 16 min. the complement of the altitude of the reflected spot, and draw C B: again, take out the Secant of 42 deg. 9 min. and fixing one foot



of the Compasses in the point C, with the other draw the small arch at F, then take out the Secant of 37 deg. 16 mi. and with one foot fixed in B, with the other crosse the arch

at

at F, draw C F and B F, and with the Radius of the line of Chords, draw the arch D E K, and divide the angle C F B (by making the arch D E equal to E K) into two equall parts, draw the line F G to cut the line C B in G. Lastly, draw the line A G, so shall A G being measured in the tangent scale appear to be 22 degrees 39 minutes, whose complement 67 deg. 21 min. is the altitude of the pole or perpendicular of the glass on the Ceiling, and the angle C A G is the angle of distance, between the Suns place, and the pole of the glass being 54 deg. 54 min. out of which take 25 deg. 46 min. the distance from the Suns place to the West point, rests 29 deg. 8 min. whose complement 60 deg. 52 min. is the declination of the plain of the Glasse from the North,

So then it appears that,

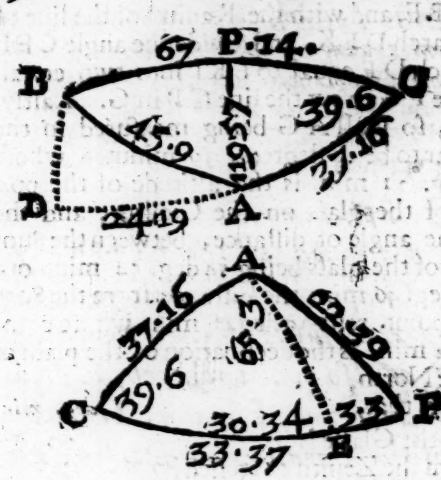
	deg.	min.
The declination of the Glasse is	60	52
Its reclination from the Zenith expressed by the pricked arch or Semicircle	67	21

Now if you desire to calculate it by the Canon, *you may use these proportions.*

I. As the Radius,
Is to the Co-sine of B A C, 119 deg. 57 m. or 60.3.
So is the Tangent of B A, 42 deg. 9 min.
To the Tangent of A D, 24 deg. 19 min.

II. As the cosine of A D, 24 deg. 19 min.
Is to the cosine of D C, 61 deg. 35 min.
So is the cosine of B A, 42 deg. 9 min.
To the cosine of B C 67 deg. 14 min.

III. As the sine of D C 61 deg. 35 min.
Is to the sine of D A 24 deg. 19. min.
So is the Tangent of B A C, 119. d. 57 m. or 60 d. 3 m.
To the Tangent of B C A, 39 deg. 6 min.



Take halfe the arth B C, to wit 33 deg. 37 min. and let that be one of the sides of the lowermost triangle C A P, where (as in the uppermost) you have given two sides and the angle included to finde A P and C A P, and the worke is the same, only in that the perpendicular fals without the Triangle and in this it fals within.

I. As the Radius.
Is to the cosine of A C P. 39 deg. 6 min.
So is the Tangent of *C A* 37 deg. 16 min.
To the Tangent of *C E*, 30 deg. 34 min.
Which being taken out of C P, 33 deg. 37 min.
There will remaine 3 *d.* 3 *m. for E P.* Then say

II. As the cosine of *C E* 30 deg. 34 min.
Is to the cosine of E P, 3 deg. 3 min.
So is the cosine of *C A* 37 deg. 16 min.
To the cosine of A P 22 deg. 39 min.
The Pole of the glasse Then,

III As the sine of A P 22 deg. 39 min.
Is to the sine of *A C P*, 39 deg. 6 min.
So is the sine of *C P*, 33 deg. 37 min.
To the sine of *C A P*, 65 deg. 3 min.

Which

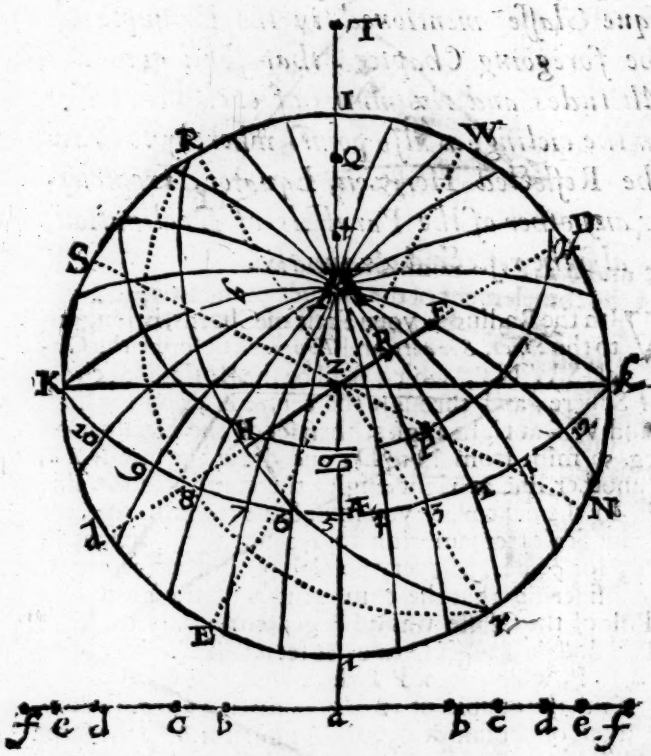
Which being taken out of the angle B A C, 119 deg. 57 m. rests 54. d. 54 m. the angle of distance between the Suns place and the Pole of the glasse.

CHAP. XXIV.

How to project the Sphere reflected from the oblique Glasse mentioned in the Example of the foregoing Chapter, that shall give the Altitudes and Azimuths of each houre-line on the cieling, as also points whereby to draw the Reflected Horizon, Equator, Tropicks, or any other of the Parallels of Declination, as also the reflected Azimuths.

WIth the Radius of your Scale of Chords, belonging to the *Sines, Secants* and *Tangents*, describe the Circle S W N E, which shall be the Horizontal circle of the Sphere, and through the centre Z draw the lines S N and W E at right angles, then set off the Declination 60 deg. 52 min. from N to D, and draw the line D Z *d*, and another line at right angles thereunto, as the line R Z *r*. In the next place you must have recourse to your Tangent Scale, remembring to account the Tangent of 45 deg. for 90 de. and every portion thereof accordingly, and considering that the complement of the altitude of the Pole of the Glasse was 22 deg. 39 min. take it out of the said double Tangent Scale, & set it from Z, in the line D Z *d*, to P, which point P is the Pole of the Glasse, as is beforesaid, the double of 22 deg. 39 mi. is 45 deg. 18 min. take it out of the said Scale, and set it from Z on the same line D Z *d* from Z to F, which point F is the Pole of the reflected Horizon, and through which point all the Azi-

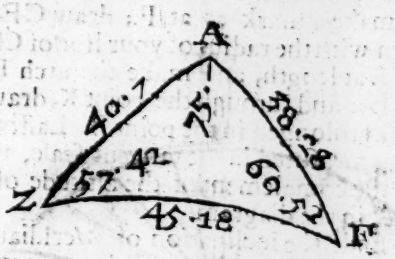
muths must passe, if you desire to draw them: Then take out of the same Scale, the complement of 45 deg. 18 min. to wit, 44 deg. 42 min. and set it off on the line D Z 4 from Z to H, so shall H be the point through which the reflected Horizon must pass, double 45 deg. 18 min. makes 90 deg.



36 min. take it out of the same scale, and set it off on the same line from Z to *h*, so shall the point *h* be the centre of the

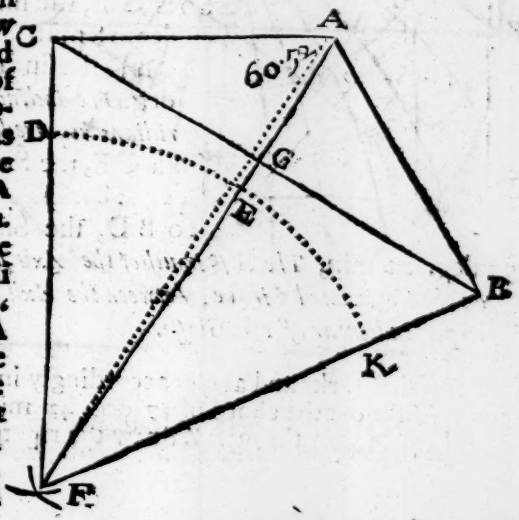
the reflected Horizon R H r. The next thing will be to find the reflected axis which is done by resolving the triangle Z F A wherein you have given,

		deg.	min.
1	The angle Z F A the declination	60	52
2	The side Z F, the pole of the reflected horizon	45	18
3	The side A F the comple. of the lat. of the place	38	28



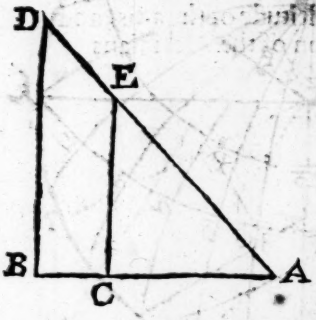
To find A Z F the azimuth of the axis
Z A the complement of the altitude of the axis, and
F A Z the angle of Inclination of the *Meridians*

But I shall shew you how you shall find the altitude of the axis geometrically, as thus: draw the right lines A C and A G, including the angle of declination, 60 deg. 52 m. make A C equal to the tangent of the complement of the latitud 38 deg. 28 m. & A G equal



to the tangent of 22 d. 39 m. the complement of the altitude of the pole of the glass; then from C through the point G, draw a line at length, and from A draw another right line at length to cut the line C G (prolonged) at right angles, as the pricked line A F; then take out the secant of 38 deg. 28 min. and fixing one foot of your compasses in the point C, bring the other foot to touch the line A F, and there make a mark as at F; draw C F; draw also F G: Then with the radius of your line of Chords, draw the arch D E at length, and make the arch E K equal to the arch D E: and through the point K, draw F B to cut the line C G prolonged in the point B. Lastly, draw B A, which being measured in the tangent scale, will appear to be 40 deg. the complement of the altitude of the axis equall to Z A in the diagram.

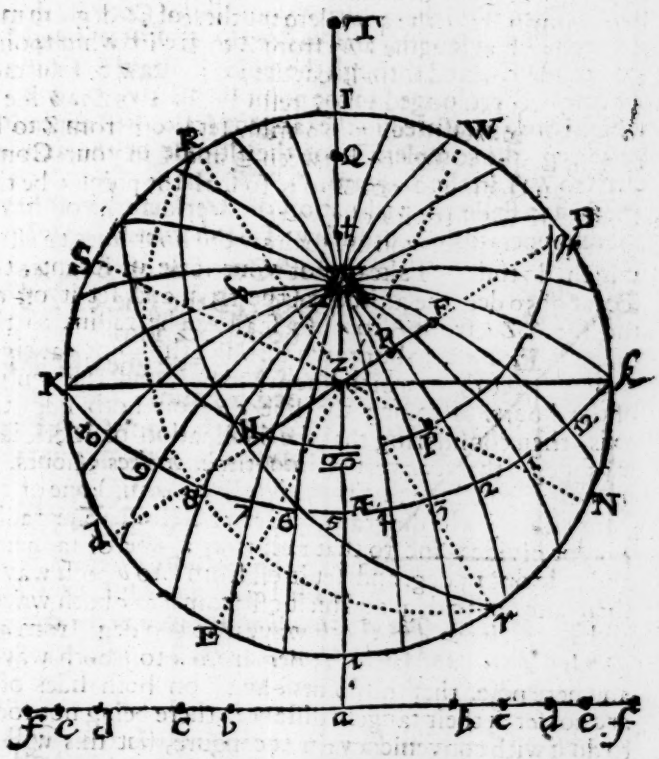
Then to finde the inclination of *Meridians*, you have but one operation in ordinary Trigonometry, to wit.



As A C the sine of Z A, 40 d
Is to A B the sine of Z F A
60 deg. 52 min.
So is C E, the sine of Z F 45
deg. 18 min.
To B D the sine of Z A F 75
deg. *The inclination of Meridians required.* And,
So is C E, the Sine of F A 38
deg. 28 min.
To B D, the Sine of F Z A
57 deg. 42 min, *The Azimuth of the Axis, or the distance on the Horizontal Circle, between the Axis and the Pole, or perpendicular of the Glasse.*

Set off those arks and angles accordingly in the diagram thus. Take out the chord of 57 deg. 42 min. and set it from D to I; and through Z draw the right lines at right angles

angles to one another I Z *i*, and K Z *k*, then return to your tangent scale accounted as a double tangent, and take out 40 deg. the complement of the altitude of the axis, and set it off in the line I Z *i*, from Z to A, which point A shall be the pole of the reflected Equator. In the next place, take



out 50 deg. the altitude of the axis, and set it off on the same line from Z to Æ, in which point the reflected Equa-

tor ſhall cut the axis: Double Z A 40 deg. makes 80 deg. take it out and ſet it from Z to Q, ſo ſhall Q be the centre of the reflected Equator K E I.

Then to draw the reflected Tropick of *Cancer*, obſerve theſe following inſtructions, which may alſo direct you in the drawing of all or any of the parallels of declination. To the Complement of the altitude of the axis 40 deg. adde the Suns greateſt declination 23 deg. 31 min. makes 63 deg. 31 min. take the complement thereof 26 deg. 29 mi. and ſet it off on the line I Z ♋ from Z to ♋, in which point the Tropick of *Cancer* ſhall cut the axis. Again, ſubſtract 23 deg. 31 min. from 40 deg. reſt 16 deg. 29 min. adde it to 90 deg. makes 106 deg. 29 min. ſet it off from Z to T; take half of the diſtance between ♋ and T in your Compaſſes, and ſet it off from ♋ to *t*, ſo ſhall the point *t* be the Centre of the Tropick of *Cancer*.

In the next place you are to draw the hour lines, to effect which, do thus. Take out of your ſcale of ſecants, the ſecant of 50 deg. the altitude of the axis, and ſet it off on the line A Z *i*, from A to *a* ſo ſhall A *a* be radius to the tangent line *c a c*, to be drawn through the point *a* at right angles thereto; in which line are to be found the centres of the hours. Prolong the line *c a c* on both ſides the axis, then conſidering that the inclination of Meridians is 75 deg, that converted into time, makes 5 hours, ſo you may conclude that the axis falls on (or is) one of the hour circles in the diagram. Open a ſector to the radius A *a*, or divide a line to that radius as a line of tangents, and take out 15 deg. and ſet it off from *a* to *b* both wayes; then take out 30 deg. and ſet it off from *a* to *c* both wayes; and 45 deg. from *a* to *d* both wayes, and 60 deg. from *a* to *e* both wayes: and laſtly, 75 deg. from *a* to *f* both wayes: and here note, that the points *e* and *f* on both ſides of *a*, are not ſet at their tangent diſtances, there being not room to do it with conveniency in the figure, but this will be well enough underſtood by all; This being done, fix one foot of the compaſſes in the point *a*, and extend the other

to

to A, and through A, draw one of the hour circles to touch the Horizontall circle on both sides: Then fix one foot of the compasses in the point A, and extend the other to A, and through A draw another hour circle: proceed thus from point to point, and through A draw all the hour circles; and here note, that one extent of the compasses drawes 2 hour circles in this diagram, by reason the axis falls on (or is) one of the hour circles.

The next thing will be to number the hours aright. Now the inclination of Meridians being 75 deg. or 5 hours in time, shewes that the hour of 12 is the 5th. hour from the axis to be taken on that side of the axis that is contrary to the side where the reflected Horizon and the reflected Equator do intersect within the horizontall circle WNE. And note that in this as in all other reflected Dials, the reflected Horizon and reflected Equator do alwayes interfect in the hour circle of six.

Now there remains nothing but to measure the altitudes and azimuths of the hour lines in the diagram, and accordingly set them off on the Cieling, with a string and a Quadrant, as was shewn in taking the altitude and azimuth of the reflected spot, if you please you may make a Table of the altitudes and azimuths for the Equator and moſt convenient Tropick (2 points being enough to draw an hour-line on any plain Cieling; but if it be irregular, you may take out points also from the reflected Horizon, or may draw any other parallel of declination in the diagram, and accordingly set it off.

Now the altitudes and azimuths are thus taken, as suppose for the Equator. Extend the Compasses from the centre of the diagram Z, to the point where the hour-line cuts the Equator, and measure that in your scale of tangents double ark, and that will give you the complement of the altitude, do so for every hour, and set down each altitude as here you see in the Table annexed.

Hour	*Angl at A*	*Altitude in Eq.*	*Azimuth in Eq.*	*Altitud in ☉*	*Azi. in ☉*
10 12	75	9 34	78 24	27 16	85 5
9 1	60	18 45	66 9	36 54	83 10
8 2	45	27 2	53 33	46 16	69 45
7 3	30	33 30	37 00	54 41	52 28
6 4	15	38 23	19 17	61 03	29 21
0 5	60	40 0	00 00	63 31	00 00

Then to take the azimuths, lay a Ruler to *Z* to pass just over the hour-line at its intersection in the Equator, observe where the Ruler cuts the Horizontall circle, and there make a mark; Extend your Compasses from that mark, either to the point where the Axis cuts the Horizontall circle, or to the points of East, West, North or South, as shall be most convenient in respect of the situation; and that shall be the azimuth of that hour-line from the Axis East, West, North or South points respectively in the Table they are accounted from the Axis, which you may reduce at pleasure, and do the like for the Tropick.

So having 2 points in the Cieling for each hour, draw streight lines through them at a convenient length (respecting the Tropicks, as being the Suns utmost course North and Southward) and your Dial is finished.

Note that in this Chapter, as those that follow, I call the streight line passing through A and Z the Axis, which is no other then the Meridian or Substile of an Horizontall Dial, whose co-latitude is Z A.

CHAP.

CHAP. XXV.

How to project the Sphere for all other kinds of Dials reflected from oblique Glasses.

TO make all plain, and leave nothing doubtfull in this busines, I have propoſed to my ſelf briefly to make mention of 3 other varieties of reflected Dials. The firſt already ſpoken of is ſuch, as that the declination and reclination of the Glaſs, cauſeth the reflected Axis to fall juſt on one of the hour-lines. The next and ſecond variety ſhall be ſuch, as that the reflected axis ſhall fall between 2 hour-lines; and you may take notice, that in the firſt and this ſecond, the North pole is elevated, and the reflected Zenith point happens to be within the horizontal circle. The third variety ſhall be ſuch, as in it alſo the North pole ſhall be elevated, but the reflected Zenith point ſhall fall beyond or without the Horizontall circle. And the fourth and laſt variety ſhall be ſuch, as that therein the South pole ſhall be elevated, and the reflected Zenith point ſhall fall alſo without the Horizontall circle, and of all theſe I ſhall need to ſay little, but referre the Reader to their reſpective Schemes and Tables, only ſet down the dimenſions of ſome of the arks and angles.

In the ſecond Examle you have given,

		deg.	*min.*
1	The Latitude of the place	51	32
2	The Suns declination North	22	20
3	The Suns Altitude afternoon	39	50
4	The Suns Azimuth Weſterly from South	75	16
5	The Altitude of the ſpot of reflection	54	40
6	The Azimuth of the reflected ſpot So. Eaſt	90	00

By the foregoing instructions you shall find

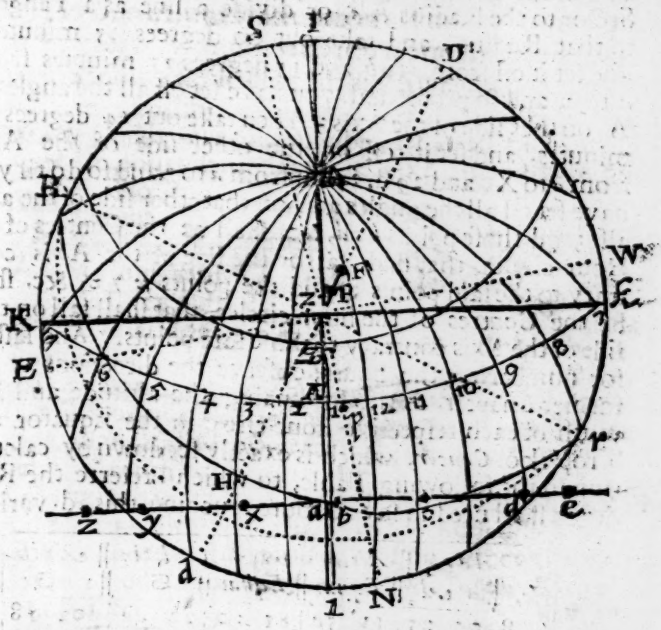
	deg.	*min.*
The declination of the Glasse to be westerly from South	40	2
And its declination from the Zenith, as appears by the pricked arch	80	3
Whose complement Z P is the pole of the glasse.	9	57

Now to find the other requisites, to wit, the Altitudes and Azimuths of the Axis, as also the inclination of Meridians, observe the forementioned directions relating hereunto; & note that the nature of the Triangle Z F A in the first Example, and of the Triangle Z F A in this Example, differ only in this, that whereas in that Example the angle at F was acute, and was the declination of the Glasse, in this Example the angle at F is obtuse, and is the Complement of the declinatioe to 180 deg. to wit, 139 deg. 58 min. So then you have given

	deg.	*min.*
1 The angle Z F A the compl. of the declin.	139	58
2 The side Z F the pole of the reflected Hor.	19	54
3 The side A F the com. of the lat. of the plac.	38	28
And by the instructions before set down, you will find A Z F the Azimuth of the Axis to be	29	19
Z A the complement of the altit. of the axis	54	58
And F A Z the angle of Inclin. of merid.	15	25

Set

Set off those arks and angles as is before directed, and considering the inclination of Meridians to be 15 deg. 25 min. take out of it an whole equinoctiall hour, to wit, 15



deg. rest 00 deg. 25 min. for the angle at A, proper for that hour-circle that falls neerest the Axis, on that side thereof where the hour-circle of 12 happens to fall; then take the complment thereof to 15 deg. to wit, 14 deg. 35 min. and that shall be the angle at A, for the hour-circle that falls neerest the axis on the other side thereof, to wit, that side where the reflected Horizon and Equator intersect: Then proceed to adde 15 degrees to each hour, and you have the angles at A for each respective hour-circle, as by the Table following appears: Then having made A e equall

equall to the ſecant of the altitude of the axis, to wit, 35 degrees 2 minutes: and through the point *a* drawn an infinite line at right angles thereunto. Open the Sector to the Radius A *a*, or divide a line as a Tangent to that Radius, and take out 00 degrees 25 minutes, and ſet it off from *a* to *b*, and 15 degrees 25 minutes from *a* to *c*, and ſo proceed till you have ſet off all the angles at A, on that ſide of the Axis; Then take out 14 degrees 35 minutes, and ſet it off on the other ſide of the Axis from *a* to X, and 29 d. 35 m. from *a* to *y*, and ſo do til you have ſet off all the angles at A, on that other ſide of the axis alſo; and thoſe points *b c d*, &c. ſhall be the Centres of the Hour-circles, that ſhall fall on the ſide of the Axis contrary to the ſaid points; and the points *x y z*, &c. ſhall be the Centres of the hour-circles, that ſhall fall on that ſide of the Axis contrary to thoſe ſaid points. And laſtly; for numbering the hours, obſerve the directions of the former Chapter, as alſo for finding the altitude and azimuth of each reſpective hour-circle in the Equator and Tropick of *Cancer*, which is exactly ſet down by calculation in the following Table, to which I refetre the Reader, & ſhall need to ſay no more, touching this 2d. variety;

Ho.	Angl. at A	Alt. in Equat	Ar. in Equat	Alt. in ☋	Ar in ☋
8	75 25	11 54	81 30	24 44	102 18
9	60 25	23 50	71 57	36 51	94 50
10	45 25	35 05	60 30	49 09	86 49
11	30 25	44 55	45 39	61 07	73 58
12	15 25	52 08	25 39	72 22	53 35
1	00 25	64 58	00 44	78 33	01 55
2	14 35	52 25	24 23	72 54	51 44
3	29 35	45 24	44 26	61 54	73 58
4	44 35	35 40	59 47	49 49	85 58
5	59 35	24 29	71 23	37 40	92 38
6	74 35	12 34	81 00	25 23	101 36
7	89 35	00 20	89 46	13 34	109 24

In

In the third variety you have given,	deg.	min.
1. The Latitude of the place	51	32
2 The Suns declination North	20	13
3 The Suns Altitude afternoon	56	33
4 The Suns Azimuth westerly from South	26	00
5. The Altitude of the reflected spot	12	40
6. The Azimuth of the spot	57	56
Work as is before taught, and you shall find the declination of the glass to be South East	30	00
And its reclination from the Zenith, as by the pricked Arch appears	42	00
Whose complement Z P is the pole of the Glass	48	00

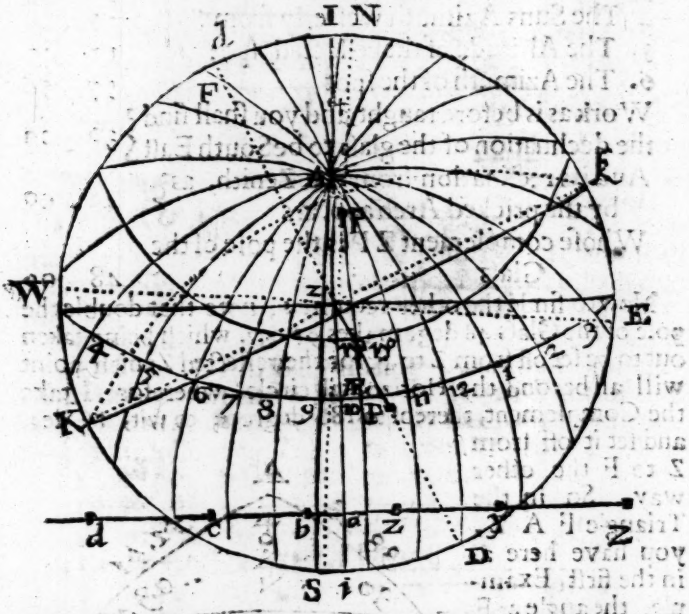
Now to finde the other requisites, note that double the pole of the Glass 48 deg. makes 96 deg. which being taken out to be set off from Z to F, for the reflected Zenith point will fall beyond the Horizontal circle, wherefore I take the Complement thereof to 180 degrees, to wit, 84 deg. and set it off from Z to F the other way. So in the Triangle F A Z, you have here as in the first Example, the angle at F acute, to wit, the declination of the Glasse, 30 degrees, the side Z F 84 degrees, and the side F A 38 deg. 28 min. to find the rest, to wit,

	deg.	min.
1 The angle *A Z F* the azimuth of the azis	23	18
2 The side *Z A* the com. of the alt. of the axis	51	51
3 And the angle *F A Z* in this Exam. obtuse The inclination of Meridians	140	47

Take the complem. thereof to 140 deg. to wit, 39 13

And.

And that shall be the angle at A between the axis and the hour-circle of 12 on the other side, to wit, the South East side of the axis. The reflected Horizon falls near the Zenith, by reason the Pole thereof F falls near the Ho-



rizontal circle. And note that in this Example, the Tropick next to Z is the Tropick of *Capricorn*, and fittest to be used in setting off the hour-lines for this Dial, the operation for finding points for both Tropicks, is briefly hereunder inserted, and I hope will be easily understood.

To

To	51	31		*From*	51	51	
Adde	23	31		*Subst.*	23	31	
Sum	75	22		*Rests*	28	20	
Comp.	14	38	*Equal to* ♈ ♍	*Comp.*	61	40	*Equal to* ♎ ♓
From	51	51		*To*	51	51	
Subst.	23	31		*Adde*	23	31	
Rests	28	20		*Sum.*	75	22	
Adde	90	00		*Adde*	90	00	
Sum.	118	20	*Equal to ZT*	*Sum*	165	22	*Equal to ZT*

Halfe the distance between ♋ T, and ♑ T; gives the centres of the Tropicks.

Ho	*Angle at A*		*Alt. in Equa.*		*Az. in Equa*		*Alt. in* ♑		*Az. in* ♑	
3	84	13	00	37	86	25	18	37	103	44
2	69	13	6	23	76	48	30	10	97	30
1	54	13	27	22	66	00	41	56	90	46
12	39	13	37	31	52	53	53	37	77	46
11	24	13	45	49	36	4	64	44	64	14
10	09	13	50	55	14	43	73	16	30	40
9	05	47	51	29	9	19	74	33	20	17
8	20	47	47	20	31	34	67	2	56	42
7	35	47	39	38	79	24	56	15	74	47
6	50	47	29	47	63	15	44	37	86	19
5	65	47	18	49	74	28	32	50	95	35
4	80	47	7	14	84	17	21	13	103	47

I referre you to the Scheme and Table here following, for finishing this Dial in the same manner as the forgoing, and proceed to the last variety in which you have given,

		deg.	min.
1	The Latitude of the place	51	32
2	The Suns declination South	23	31
3	The Suns Altitude afternoon	13	48
4	The Suns Azimuth South westerly	14	03
5	The Altitude of the reflected spot	30	00
6	The Azimuth of the spot	75	58

	deg	min.
Work as by the forementioned instructions, and you will find the decli. of the glass to be So. East? And its declination as by the pricked arch appears	30	00
	30	00
Whose Complement Z P is the pole of the Glasse	60	00

And here you see that the pricked arch falls between the Zenith of the Horizontal instrument and the North pole (*p*) and therefore that pole is hid from the eye, and the South pole elevated. Now to find the other requisites, note that seeing the double of the pole of the Glasse, to wit, twice 60 degrees, or 120 degrees, being set off that way would passe farre beyond the Horizontal Circle; take the complement thereof to 180 deg. to wit, 60 degrees, and set it off from Z to F the other way: So shall F be the reflected Zenith point, and the nature of the Triangle F A Z agreeth with that of the last mentioned Example, in which you have given,

1. The

		deg.	min.
1	The angle at F the declination of the glass	00	03
2	The side Z F	60	00
3	The side F A	38	28

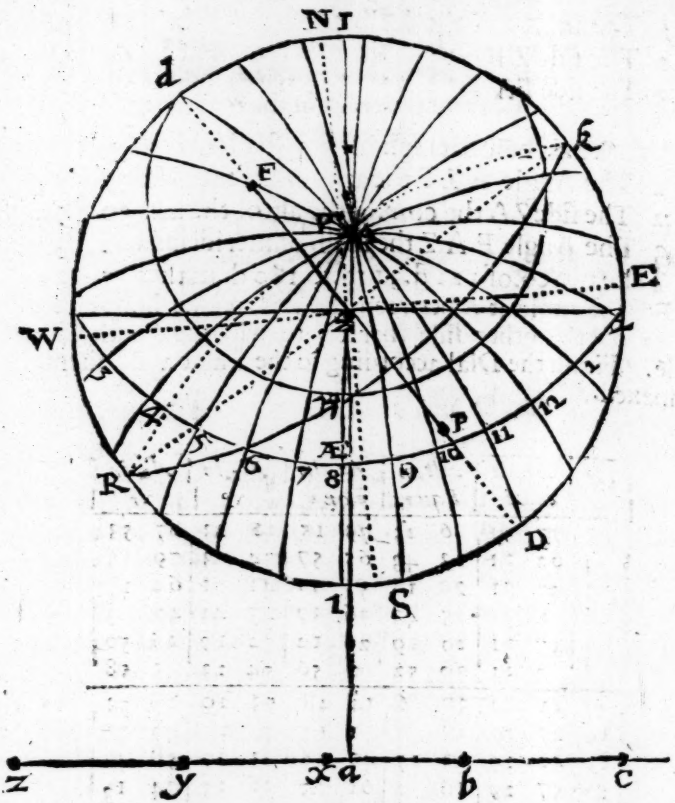
Work as is before taught, & you shall find,

		deg.	min.
1	The Angle A Z F the azimuth of the axis	37	17
2	The side Z A the com. of the alt. of the axis	30	54
3	The Angle F A Z the incli. of meridians	122	31

Take the cō. of 122 d. 31 m. to 180 d. makes 57 29

For the angle at A between the axis and the hour-circle of 12 on the other side thereof, to wit, the South East side. Finish the Dial according to the Table and Scheme annexed.

Ho	Angle at A	Alt. in Equa.	Az. in Equa	Alt. in ♈	Az. in ♈
3	77 31	6 28	79 15	26 23	87 53
4	62 31	13 43	65 57	34 3	79 3
5	47 31	20 18	51 51	41 21	64 14
6	32 31	25 40	36 37	47 42	47 5
7	17 31	29 19	20 12	52 19	26 50
8	2 31	30 52	2 56	54 23	3 58
9	12 29	30 6	14 28	53 20	19 33
10	27 29	27 6	31 14	49 28	40 38
11	42 29	22 15	40 18	43 37	58 48
12	57 29	16 2	61 19	36 33	74 13
1	72 29	8 53	74 51	28 58	88 7
2	87 29	1 18	87 50	21 17	100 32



Now in case Z A, be more then 66. 29 then the places where the Tropicks must cut the axis, and their centers are thus found, as suppose Z A to be 86. 40 and first for the Tropick neerest to A.

86 40
23 31
---
110 11

Here you must set off the excesse above 90 deg: to wit, 20 deg. 11 min. from Z towards A, on the Axis, for the point where one of the Tropicks cuts the Axis.

Then

86 40
23 31
63 09
90 00
153 09

Then to finde the Centre for that Tropick.

Set off 153 deg. 9 min. from Z to T, and take halfe the distance between the point first found and T, and the point of the compasses will designe *t* for the centre required.

Next for the Tropick remotest from A.

86 40
23 31
63 09
26 51

Set off 26 degrees 51 min. on the Axis beyond A Z, from Z to the place where the other Tropick cuts the Axis.

86 40
23 31
110 11
90 00
200 11

Then to finde the Centre for that Tropick.

Which being more then 180 degrees, you may conclude the centre for that Tropick is to be found the other way, to wit, within or beyond that part of the Sphere contrary to that where the point T for the other Tropick was found: So take the Complement to 360 deg, to wit, 159 deg. 49 min. and set it off accordingly from Z to T, and let the point of the compasses rest in the mid way between the last found point and T, as at *t*, and that *t* shall be the centre for that Tropick.

Another way to finde the Centres by the Tables of Naturall Tangents.

Let the Example be the Centre for the Tropick farthest from A.

From Z to the first point is 26. 51. the halfe is 13. 25½, the Natural Tangent is 23870

From Z to T is 159. 49, the halfe thereof is 79. 54½, the Natnrall Tangent 561800

Their sum is 585670

Halfe the sum is 292835

Which

Which halfe ſumme is the Naturall Tangent of 71 deg. 9 min. and is equal to the diſtance between the point firſt found and *t*, which is the centre required.

CHAP. XXVI.

How to effect the worke of the foregoing Chapters by Calculation, without the trouble of drawing a Scheme.

HAving found the altitude of the axis, as alſo the Inclination of Meridians, that is the angle of each hour-circle at A, by any of the foregoing inſtructions, collect them into a Table (as you ſee done in the Table belonging to the laſt variety which I ſhall take for an example, and therein the houre of 6) and make uſe of theſe following proportions.

And firſt for the Equator.

I. As the Radius.	90	00
Is to the coſine of the altitude of the Axis	59	06
So is the coſine of the angle at A	32	31
To the ſine of the altitude in the Equator	25	40
II. As the ſine of the altitude of the axis	59	06
Is to the Radius	90	00
So is the Tangent of the Angle at A	32	31
To the Tangent of the Azimuth from the axis	36	37

Then for the Tropick

I. As the Radius.	90	00
Is to the Tangent of the altitude of the axis	59	06
So is the coſine of the angle at A	32	31
To the Tangent of a fourth arke, to wit	26	47
Which being taken out of 66. 29 there reſts	39	42

Then

Then say.

As the cosine of the fourth arke	26	47
Is to the cosine of the residue	39	42
So is the sine of the altitude of the axis	59	06
To the sine of the altitude in the Tropick	47	42

Note that when the angle at A is above 90 you must take the fourth arke out of 113. 31 *in steed of* 66. 29

II. As the cosine of the altitude in the Tropick	47	42
Is to the Sine of the angle at A	32	31
So is the cosine of the Suns greatest decli	23	31
To the sine of the Azimuth from the Axis	47	05

If the reader be not furnished with the Canon of Sines and Tangents (by which things are one most exactly) or is not acquainted with the use of them, he shall finde in the second Section of the 14 Chapter, as also at the end of this Treatise in a short Appendix, some breise instructions how to effect his desires exactly enough by the Scales of Sines and Tangents on the Ruler.

CHAP. XXVIII

How to finde the Altitudes mentioned in the foregoing Chapter Geometrically: By which method the Altitudes of all the hours of any Diall in any parallel of Declination, and for any Latitude, are speedily found.

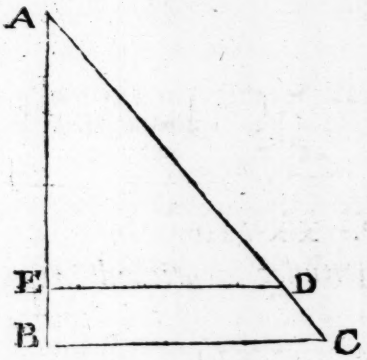
IN the first place you are to take notice that by the altitude of the Axis is meant the Latitude of the place, or height of the Stile, where that plain would be an Horizontal plain: accordingly finde the Ascensional difference by the proportion following,

As the cotangent of the altitude of the axis	59	06
Is to the Radius	90	00
So the Tangent of the Suns greateſt declination	23	31
To the Sine of the aſſentionall difference	46	38

In the next place finde the Meridian altitude of the Sun in the Tropick you intend to make uſe off, in all the four varieties I have choſen the Tropick neareſt to Z A, which in this example is the Tropick of V *S*.

To the Complement of the altitude of the Axis 30,54 add 23.31 makes 54. 25 for the Meridian altitude of the Sun in that Tropick in this example.

Having found the Meridian altitude, proceed thus: With your ſmall Square draw the lines A B and B C, of ſufficient length, that done, fix one foot of the compaſſes in the middle of your Scale of verſed ſines (now vſed as a Scale of ſines) & extend the other foot to the ſine of the Meridian altitude 54. 25 and ſet off that extent from B to C, then add 90 deg. to the aſſentionall difference 46 38 makes 136.38 take this out of your Scale of Verſed ſines, by fixing one foot at the begining thereof and extending the other to 136.38, and with that extent fixing one foot in the point C, extend the other to the line A B, and croſſe it with a ſmall arch as at A, from which interſection draw the line A C; then conſidering the angle at A from the hour of 6 (which example we make uſe of here) is 32.31 take it out of the ſame ſcale of verſed ines, and ſet it from C to D and draw the line D E parallel



parallel to B C or take the neereſt extent from the point D to the line A B (which is all one) and that extent of the Compaſſes or length of the line D E being meaſured as a ſine from the point 90, on the verſed ſcale, will give you 47. 42 the altitude required for that hour in that Tropick.

For by the Tables of Naturall ſines.

As A C 172 697 the verſed ſine of 136.38, the aſcenſionall difference and 90 added together

Is to B C 81327 the right Sine of the Meridian altitude 54. 25

So is A D 157021 being A C leſſe the Verſed ſine of 32.37 the angle at A

To D E 73963, the right Sine of 47.42 the altitude required.

And thus you may ſet off all the other houres by taking the angles at A out of the Scale of Verſed ſines and ſetting them off ſeverally from C on the line A C, and from thoſe reſpective points draw lines parallel to B C, or take the neereſt diſtances from thoſe ſeverall points to the line A B, and thoſe lines or diſtances being meaſured in the ſcale of Verſed Sines from the middle, as right ſines, will give you the Sine of the altitude, of every reſpective houre for that declination.

Note that this Method is of ſpeciall uſe for the ſpeedy finding of the Suns altitude at any houre or part of an hour aſſigned any time of the yeare in reference to what above, and contrarily to finde the hour of the day or part of the houre at any aſſigned altitude, the firſt being ſet down, the ſecond will be ſo eaſy, as that I ſhall only mention the proportions. Suppoſe then (making uſe of the ſame example) that the altitude 47. 42 is given, and the houre required, having framed your Triangle A B C,

according to what is given, fix one foot of your Compasses in the point of 90 of the scale of versed sines, and extend the other to the right sine of 47. 42. the given altitude, and with that extent placing one foot in the line A C: moving it upward and downward untill the other foot shall just touch the line A B, there make a marke as at D, then measure D C in your versed scale, and you shall finde it to be the versed sine of 32, 31, the houre required: for as B C is to A C, so is D E to A D, which taken out of A C there remains D C.

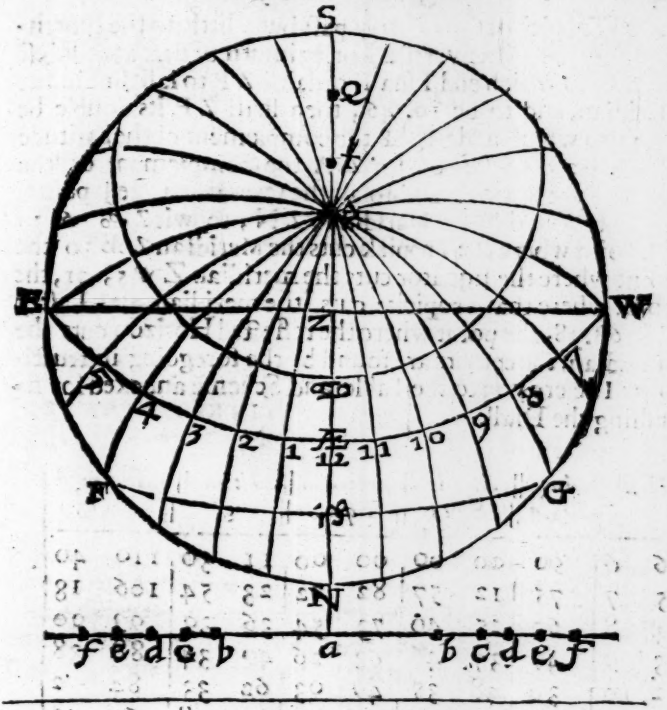
CHAP. XXVIII.

How to set off the Houre-lines on the Cieling for a Diall reflected from a Glasse that lyeth parallel to the Horizon, for the Latitude of London, 51 *deg.* 32 *min.*

HAving drawn the Meridian line on the Cieling, you will see what Hours will come on, and accordingly take them out of the annexed Table, and set them off by their Altitudes and Azimuths, according to the direction of the 23 Chapter. I have added a Scheme for the further use and delight of the young Practitioner, though there needed none.

Hour	*Ang. at A*	*Alt. in Equat*	*Azi. in Equat*	*Alt. in* ♋	*Azim. in* ♋
8 4	120			1 34	127 3
7 5	105			9 30	116 3
6 6	90			18 12	105 8
5 7	75	9 17	78 6	27 23	94 13
4 8	60	18 7	65 40	36 42	82 00
3 9	45	26 5	51 56	45 42	68 10
2 10	30	32 36	36 24	53 45	50 51
1 11	15	36 56	18 52	59 42	27 56
12	00	38 28	00 00	61 59	00 00

CHAP.



CHAP. XXIX.

How to set off the hour-lines on the Cieling reflected from a Glasse that only reclineth.

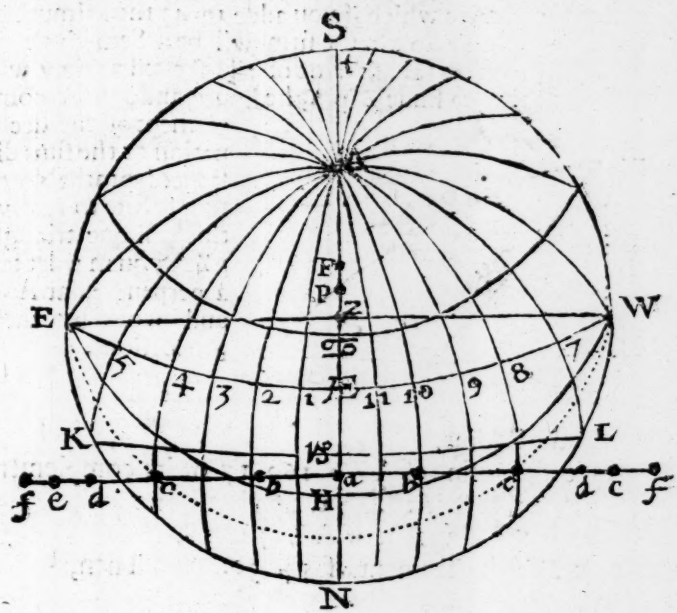
LEt the Lat. of the place be 51. 32. I finde for conveniency in respect of the situation of the Roome where I intend to make the Diall, and to prevent the great excursion of the lines, as also for ease in calculation or projecting the Sphere, to cause the Glasse only to recline so much from the Zenith towards the South, as that the re-

flected Tropick of *Cancer* may pass but a little to the Northward of the prime vertical, or azimuth of East and West W Z E, to which end I shall ordaine Z P to fall just in the Meridian, and to be 10. 46, then shall Z F its double be 21.32, to which adde 38.28 the complement of the Latitude of the place makes 60 for Z A the complement of the altitude of the axis, and so all the several reflected points are to be found in the Meridian S Z N, to wit Z ☋ 6, 29 the point where the Tropick cuts the Meridian Z Æ 30 the point where the Equator cuts the meridian Z ♈ 53. 31, the point where that Tropicke cuts the meridian, and Lastly Z H 68. 28, the point where the reflected Horizon cuts the meridian; the centers are found by the foregoing instructions. I refere you to the Table and Scheme annexed for finishing the Diall.

Hour		*Ang. at A*	*Alt. in Equat*		*Azi. in Eqnat*		*Alt. in* ☋		*Azim. in* ☋	
6	6	90	00	00	00	00	11	30	110	40
5	7	75	12	57	82	22	23	54	106	18
4	8	60	25	40	73	54	36	39	99	00
3	9	45	37	45	63	26	49	34	88	38
2	10	30	48	35	49	03	62	33	84	2
1	11	15	56	46	28	11	75	8	67	40
	12	00	60	00	00	00	85	31	00	00

Note that if the Room stand just towards the South, or very neer it, then you may cause the Reclination to be somewhat less then 10 deg. Else you will not have points in the Cieling, for some of the Hours in Cancer. *But if it decline divers degrees, then this Dial may serve in taking out such Hours as are needfull out of the Table, and setting them.*

them off according to their respective Altitudes and Azimuths in the Table mentioned. The thing is so easie as I hope I need say no more touching it.

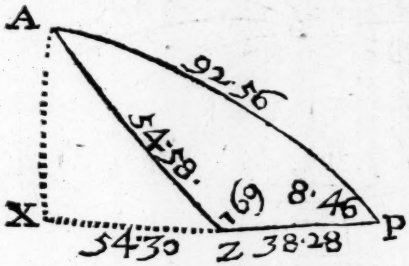


CHAP. XXX.

How to know (if at all or) at what time of the year, and time of the day, the Sunne in his own position will give you the reflected axis point.

TAke the Example of the second variety, where the altitude of the Axis is 35. 2, and the azimuth from South towards West 10. 43 so you have to deale with the Tri-

Triangle p Z A where you have given the side Z p, the complement of the Latitude of the place 38. 28 the side Z A the complement of the altitude of the axis 54. 58, and the angle p Z A 169. 17 (that is the declination of the glasse from the North 139. 58 and the azimuth of the axis 29. 19 added together, to which if you adde 10. 43 the azimuth of the axis from the South, the sum will be a Semicircle or 180. deg. as in the said scheme of the second variety will plainly appear) to finde Z p A, the houre, and p A the complement of the declination or the suns distance from the North Pole. Now to resolve this oblique triangle p Z A you may let fall a perpendicular A X, and work by these proportions.



As the Radius.
Is to the cosine of A Z p 169. 17 or its complement to 180. to wit 10. 43 which is all one
So is the Tangent of A Z 54. 58.
To *Z X* the Tangent of 54. 30. Then,

As the cosine of Z X 54. 30
Is to the cosine of X p 92. 58 or 87. 2.
So is the Cosine of Z A, 54. 58
To the cosine of 87. 4 take the complement thereof to 180. to wit 92. 56, and that is the complement of the declination or the Suns distance from the North pole for the side A p.

Then

Then to finde the angle Z p A, you have only this proportion.

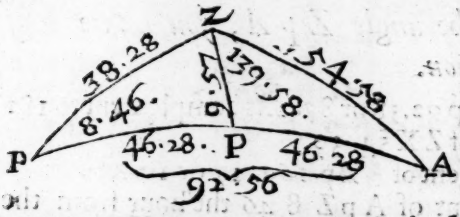
As the ſine of X p 92.58 or 87. 2 its complement to 180
Is to the ſine of Z X 54. 30
So is the Tangent of A Z p 169. 17 or 10. 43
To the Tangent of A p Z 8 46 the hour from the Meridian, which converted into time is 0 hours 35 min.

So you may conclude that when the Sun hath 2 deg. 56 min. of South declination which by the Table of the ſuns declination for every day will appear to be the 20th of September at 35 min after noon (the azimuth of the axis being South Weſt) the Sun ſhining on the Glaſſe will give you the reflected axis point required,

CHAP. XXXI.

From a point taken in the Tranſome of the Window, having aſſigned a reflected Axis by an Altitude and Azimuth taken at pleaſure, to finde the Pole or perpendicular of the Glaſſe to be there placed.

SUppoſe the altitude of the axis to be 35. 2, and its azimuth from South towards Weſt 10. 43 agreeable to the example, of the foregoing chapter, and the Triangle relating to the work thereof A Z p where you have given, firſt the ſide Z A, the complement of the altitude of the axis 54. 58, the ſide Z p the Complement of the Latitude



tude of the place 38. 28, and the angle at Z 169.17 the complement of the azimuth from South, to finde Z P the pole of the Glass. By the worke of the foregoing Chapter you may finde the side pA. the complement of the declination to be 92.56, and the angle ApZ the houre 8 deg. 46 min. draw a line from Z, as the line Z P to part the arch A p 92.56 in two equall parts, then have you to deale with the Triangle P Z p where you have given the side Z p 38, 28, the side Pp 46. 28, and the angle ZpP 8. 46 to finde the side Z P and the angle p Z P.

Worke as by the instructions of the foregoing Chapter, and you shall finde the side Z P to be 9. 57 the pole of the Glasse whose complement to 90, to wit 80. 3 is its reclination from the Zenith, and the angle p Z P 139. 58 the complement of its declination from the South Westerly to wit 40. 2.

But the sides Z p and Z A together with the angle pZ A being given, you may finde Z P and p Z P Geometrically by the instructions of the 23 Chap. which may well serve in this place, and the work of this and the foregoing Chapter may serve for instructions there, if the Reader desire to make use of the Canon.

CHAP.

CHAP. XXXII.

How to situate the piece of Glasse in respect of Declination and Reclination, according to the Diall drawn, or intended to be drawn, on the Cieling.

DRawe a reflected parallel, for that day you intend to fix your piece of Glasse, if it be the day the Sunn enters the Equinoctiall, then a straight line designes that circle on the Cieling, if at any other time then the parallel is a Curve line on the Cieling. Suppose it be the day the Sun enters *Cancer*. By the instructions of the 24 Chapter you may finde points for drawing that Tropick, which being drawn you may take out of the Table where the houres, altitudes and azimuths are collected, the altitudes and azimuths of what Houres you please, and with a string and Quadrant set off those altitudes and azimuths on the Cieling by making obscure marks with a Black-lead pen.

Then by knowing what altitude the Sun will have at those houres, or by an Horizontall Diall set up for the present use in your Window, or any other place, where the Sun may shine on it, observe when the shadow of the Sunn comes to any of those houres, on the Horizontall Diall, or when the altitude of the Sunne, taken with a Quadrant, or other Instrument, shews it to be such an houre, then drop Sement into the Socket or hole where you intend to place the Glasse, and immediately clap the Glasse thereon, and move it so, while the Sement is yet warme, as that the Sunne shineing theron may be reflected just on the point found on the Cieling, so shall the Glasse be rightly situated.

If you intend your Diall shall not have the parallels of declination, then you need only set off points, according

to the altitudes and azimuths in the Table, as is before taught, but for 2. or 3. houres at leaſt, becauſe poſſibly the Sun may not ſhine forth at ſuch an houre, but may at the next, or next after. Example for one hour, to wit the houre of 3 afternoon in the Diall of the ſecond variety, where by the Table relateing to that Diall the altitude of the houre of 3 on the Cieling (the Sunne being in the Tropick of *Cancer*) is 61. 54, and its Azimuth from the Axis 73. 58, or from the North part of the Horizon (by adding 10. 43,) 84. 41, make an obſcure marke on the Cieling, accordingly, then finde by your Table of the *Suns* altitude at his entrance into any of the ſignes, the altitude of the Sun at that hour, when the Sun is in the Tropick of *Cancer*, to wit 45. 42, ſo when by your Quadrant or other fitting Inſtruments, you finde the altitude to be ſuch, or that the ſhadow on the Horizontall Diall is juſt come to that houre, immediately fix your glaſs into the Socket at ſuch an obliquity, as that the Suns beam may reflect the ſpot of light directly on the obſcure marke on the Cieling, if you miſſe one houre you muſt take another according to the ſame directions.

Note that if you rub the piece of Glaſſe on a brick, or with a pumie Stone it will prevent a double ſpot in its reflection.

CHAP.

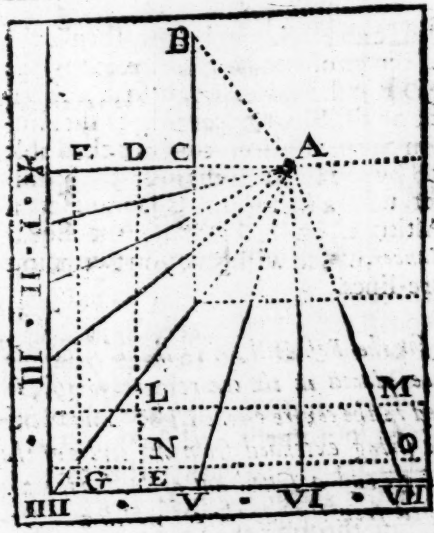
CHAP. XXXIII.

How to set off the houre-lines on the Floor of a Room, the Sun shining through a small hole made in any pain of Glasse in the Window.

SUppose the Floor to be an Horizontal plain, then is the distance from the centre of the hole to the Floor the length of the perpendicular Stile. Draw first a Meridian East or West line on the Floor, according to the situation of the Room. In the next place, consider the Table of the 28 Chapter, and by the instructions neer the beginning of the 23 Chapter, with a string and Quadrant set off the Azimuths and Altitudes on the Floor, for the Æquator and Tropick of *Cancer*, which will give you two points for drawing the houre-lines.

Note, *That whereas for the Reflected Diall the Horizontall Pastboord was to be placed in the centre of the Glasse, in this it must be placed in the centre of the Hole: And whereas also in that (the string extended from the centre of the Glasse to the Cieling, and a Quadrant applyed to it) the altitude was accounted from the side thereof which was farthest off from the Window, in this the thrid must be extended from the centre of the hole to the Floor, and the Quadrant being applyed thereto, must give the true Altitudes, to be accounted from the side neerest the Window.*

Otherwise, You may protract on paper an ordinary Horizontal Dial, and croſſe the Houre-lines with the parallels D E and F G, drawn ſquare to the Meridian, if the Window look directly towards the South, or declineth little therefrom: or if the window decline much from the South, draw alſo the parallels LM & NO, ſquare to the houre-line of Six, as in the Scheme annexed, wherein you have



B the hole in the pain of Glaſſe.

B C the diſtance from the Window to the Floor, eſtimated 1000 equall parts.

A the centre of the Diall abroad in the aſr,

A + the Meridian or Twelve a clock houreline.

A G the Tangent of 38 deg. 28 min. the complement of the Latitude.

A B C the imaginary Stile, whoſe angle B A C is 51 degrees 32 minutes equal to the Latitude of the place.

Next, Take out of your Scale of equall parts, the ſeverall diſtances on the paper pattern and ſet them down in a Table as you ſee here done.

C D 500.

	HOVRS.	From D on the parallel of DE	From F, on the parallel of FG
CD 500	1 11	0270	0370
CF 1000	2 10	0590	0800
	3 9	1010	1410
	4 8	1800	2480
	HOVRS	From L on the parallel of LM	From N on the parallel of NO
DL 2000	5 7	0650	0 470
LN 500	6 6	1310	1310
	7 5	1950	2120

Now let the distance between the Hole and the Floor be also estimated 1000 equall parts to be set off on a Lath, long Ruler, or other like material, and so may you decimally set off the parallels, and all the respective points to be found in them, by the correspondent parts taken off from the Lath or other fit Instrument, and finish the Dial.

Note, that it will be necessary to darken that part of the Glasse which is about the hole, that so the Sun-beams passing through the hole may be the cleerer discerned upon the Floor.

Here follow certain TABLES *useful in the Art of*

DIALLING.

A Table containing the arches of the Horizon, intercepted between the Meridian, and each houre line upon the Diall plaine, for Horizontall and Verticall Dialls, calculated from 30. to 60 degrees of Latitudes.

Latitudes for Hori.	11 1		19 2		9 3		8 4		7 05		Latitudes Verteals
	D	M	D	M	D	M	D	M	D	M	
30	7	37	16	07	26	34	40	54	61	49	60
31	7	51	16	34	27	15	41	44	62	30	59
32	8	05	17	01	27	55	42	32	63	11	58
33	8	19	17	27	28	37	43	20	63	49	57
34	8	31	17	54	29	13	44	05	64	24	56
35	8	44	18	20	29	50	44	49	64	58	55
36	8	57	18	45	30	27	45	31	65	30	54
37	9	10	19	09	31	02	46	12	66	10	53
38	9	22	19	34	31	37	46	50	66	29	52
39	9	24	19	58	32	11	47	28	66	56	51
40	9	45	20	21	32	44	48	07	67	21	50
41	9	57	20	44	33	16	48	39	67	47	49
42	10	10	21	07	33	46	49	12	68	11	48
43	10	22	21	29	34	18	49	44	68	33	47
44	10	32	21	51	34	47	50	16	68	54	46
45	10	43	22	12	35	17	50	46	69	15	45
46	10	54	22	33	35	44	51	15	69	35	44
47	11	05	22	53	36	11	51	42	69	53	43
48	11	17	23	13	36	37	52	09	70	11	42
49	11	25	23	33	37	03	52	35	70	28	41
50	11	35	23	52	37	28	53	00	70	43	40
51	11	45	24	09	37	52	53	24	70	59	39
52	11	55	24	27	38	15	53	46	71	13	38
53	12	05	24	43	38	37	54	08	71	28	37
54	12	13	25	02	38	58	54	29	71	41	36
55	12	22	25	18	39	19	54	49	71	54	35
56	12	32	25	34	39	40	55	09	72	05	34
57	12	40	25	50	39	59	55	28	72	17	33
58	12	48	26	05	40	18	55	45	72	28	32
59	12	56	26	20	40	36	56	03	72	38	31
60	13	04	26	34	40	54	56	19	72	48	30

The Use of the forogoing Table for the makeing of Horizontal *and* Vertical *Dials.*

WHen you have any Horizontal or Vertical Dial to make for any of these Latitudes, you haye nothing to do but to sweep an arch with your Compasses opened to the Radius of any of your Scales of Chords, and in that arch, from the Meridian line set off the degrees and minutes answering to each houre in the Table, respecting the Latitude of the place: If the Latitude have some odde minutes, you may take the part proportional as reason wil direct: The first column of the Table gives you the Latitudes for the Horizontal, and the last column for Vertical, The other columns contain the hour arches respecting the Latitudes for both Horizontal and Vertical.

The Proportion by which this Table was Calculated.

As the Radius,
Is to the Tangent of the Hour from the Meridian;
So is the Sine of the Latitude for Horizontal (or the co-sine for Vertical) Dials,
To the Tangent of the houres distance from the Meridian upon the dlain.

A TABLE of the Suns Declination for every day of the first Six moneths of the yeare 1653, &c.

	Januar		Febrna		Marc		April		May		June	
Days	D	M	D	M	D	M	D	M	D	M	D	M
1	21	44	13	46	03	24	08	36	18	05	23	12
2	21	34	13	26	03	00	08	58	18	20	23	16
3	21	23	13	05	02	37	09	20	18	35	23	19
4	21	13	12	45	02	13	09	42	18	50	23	22
5	21	02	12	25	01	49	10	03	19	04	23	25
6	20	50	12	04	01	25	10	24	19	18	23	27
7	20	38	11	43	01	01	10	45	19	31	23	29
8	20	26	11	21	00	38	11	06	19	44	23	30
9	20	13	11	00	00	N14	11	27	19	57	23	31
10	20	00	10	38	00	10	11	47	20	10	23	31
11	19	46	10	16	00	33	12	07	20	22	23	31
12	19	32	09	54	00	57	12	28	20	34	23	31
13	19	18	09	32	01	21	12	48	20	45	23	30
14	19	03	09	10	01	44	13	07	20	56	23	29
15	18	48	08	48	02	08	13	27	21	07	23	28
16	18	33	08	25	02	31	13	46	21	17	23	26
17	18	17	08	03	02	54	14	05	21	27	23	23
18	18	02	07	40	03	18	14	24	21	37	23	20
19	17	45	07	17	03	41	14	42	21	46	23	17
20	17	28	06	54	04	05	15	01	21	55	23	14
21	17	11	06	31	04	28	15	19	22	04	23	10
22	16	54	06	08	04	51	15	37	22	12	23	06
23	16	36	05	45	05	14	15	54	22	20	23	01
24	16	18	05	21	05	37	16	12	22	27	22	55
25	16	00	04	58	06	00	16	29	22	34	22	50
26	15	42	04	34	06	22	16	46	22	41	22	44
27	15	23	04	11	06	45	17	02	22	47	22	37
28	15	04	03	47	07	07	17	18	22	53	22	31
29	14	45			07	30	17	34	22	58	22	23
30	14	26			07	52	17	50	23	03	22	16
31	14	06			08	14			23	08		

A TABLE of the Suns Declination for every day of the last Six moneths of the yeare 1663, &c.

	July		*August*		*Septe.*		*October*		*Novem*		*Dece.*	
Days	D	M	D	M	D	M	D	M	D	M	D	M
1	22	08	15	12	04	24	07	15	17	40	23	09
2	22	00	14	54	04	02	07	38	17	56	23	13
3	21	51	14	36	03	38	08	00	18	12	23	17
4	21	42	14	17	03	15	08	22	18	28	23	20
5	21	32	13	58	02	52	08	45	18	43	23	23
6	21	22	13	39	02	29	09	07	18	58	23	26
7	21	12	13	20	02	05	09	29	19	13	23	28
8	21	02	13	01	01	42	09	51	19	27	23	30
9	20	51	12	41	01	19	10	13	19	41	23	31
10	20	40	12	21	00	55	10	35	19	55	23	31
11	20	28	12	01	00	32	10	56	20	08	23	31
12	20	16	11	41	00	08	11	18	20	21	23	31
13	20	04	11	21	00 S	16	11	39	20	34	23	30
14	19	51	11	00	00	39	12	00	20	46	23	29
15	19	38	10	39	01	03	12	21	20	58	23	27
16	19	25	10	18	01	26	12	41	21	09	23	25
17	19	12	09	57	01	50	13	02	21	20	23	22
18	18	58	09	36	02	13	13	22	21	31	23	19
19	18	43	09	15	02	37	13	42	21	41	23	16
20	18	29	08	53	03	00	14	02	21	50	23	12
21	18	14	08	31	03	23	14	21	22	00	23	07
22	17	59	08	09	03	47	14	41	22	09	23	02
23	17	44	07	47	04	10	15	00	22	17	22	57
24	17	28	07	25	04	33	15	19	22	25	22	51
25	17	12	07	03	04	57	15	37	22	33	22	44
26	16	56	06	41	05	20	15	55	22	40	22	37
27	16	39	06	18	05	43	16	13	22	46	22	30
28	16	22	05	56	06	06	16	31	22	52	22	22
29	16	06	05	33	06	29	16	49	22	58	22	14
30	15	48	05	10	06	52	17	06	23	04	22	05
31	15	30	04	47			17	23			21	56

The Use of the TABLE of the Suns Declination.

THe first column contains the the dayes of the Month, and the rest of the Columns, the Suns declination, just against it, respecting the Month on the head of each Columne.

By this Table, you may finde one of the three requisites for Calculateing the houre or azimuth; to wit, the Suns Declination for the day desired.

Find first the Suns place in the Ecliptick, that is to say, in what signe and deg. of the Zodiack the Sun is in; which most Almanacks will discover, that done; the proportion to finde the Declination will be this. (as Suppose for the 12 of *May* 1664. the Suns place, that day, being in 2 deg. of *Gemini*, whose distance from the next Equinoctiall point *Aries*, is 62 deg)

The proportion by which this Table was Calculated.

As the Radius.
Is to the Sine of the distance 62?
So is the sine of the Suns greatest declination 23. 31.
To the sine of the Suns declination for that day 20.40, and in the Table against that day you shall finde 20. 34, the difference is inconsiderable in Dialling, besides, the year 1664. is Leap yeare, else the difference had not been so much.

As

A Table *of the Stiles height.*

Degrees of Latitude.

Decli.	50		51		52		53		54		55		56	
	D	*M*	*D*	*M*	*D*	*M*	*D*	*M*	*D*	*M*	*D*	*M*	*D*	*M*
1	39	59	38	59	37	59	36	59	35	59	34	59	33	59
2	39	58	38	58	37	58	36	58	35	58	34	58	33	58
3	39	56	38	56	37	56	36	57	35	57	34	57	33	57
4	39	53	38	53	37	53	36	54	35	54	34	54	33	54
5	39	49	38	49	37	49	36	50	35	50	34	51	33	51
6	39	45	38	45	37	45	36	46	35	46	34	47	33	48
7	39	39	38	40	37	40	36	41	35	42	34	43	33	43
8	39	33	38	34	37	34	36	36	35	36	34	37	33	38
9	39	25	38	26	37	27	36	28	35	29	34	31	33	32
10	39	17	38	19	37	20	36	21	35	23	34	24	33	26
11	39	08	38	10	37	11	36	13	35	15	34	16	33	18
12	38	58	38	00	37	02	36	04	35	06	34	08	33	10
13	38	47	37	49	36	51	35	54	34	56	33	59	33	01
14	38	36	37	39	36	41	35	44	34	46	33	49	32	52
15	38	23	37	26	36	29	35	33	34	35	33	39	32	42
16	38	10	37	14	36	17	35	21	34	24	33	28	32	31
17	37	56	37	00	36	04	35	09	34	12	33	16	32	20
18	37	41	36	46	35	50	34	55	33	59	33	04	32	08
19	37	26	36	31	35	36	34	41	33	46	32	51	31	56
20	37	10	36	16	35	21	34	27	33	32	32	37	31	42
21	36	53	35	59	35	05	34	11	33	17	32	23	31	29
22	36	36	35	42	34	49	33	56	33	02	32	08	31	14
23	36	17	35	24	34	31	33	39	32	45	31	52	30	59
24	35	58	35	06	34	13	33	21	32	29	31	36	30	45
25	35	38	34	47	33	55	33	04	32	12	31	20	30	27
26	35	18	34	27	33	36	32	45	31	54	31	02	30	11
27	34	57	34	09	33	16	32	26	31	35	30	44	29	53
28	34	35	33	46	32	56	32	06	31	16	30	26	29	35
29	34	13	33	24	32	35	31	46	30	56	30	07	29	17
30	34	00	33	02	32	13	31	25	30	36	29	47	29	58

A Table *of the Stiles height.*

Degrees of Latitude.

Declina	50		51		52		53		54		55		56	
	D	*M*	*D*	*M*	*D*	*M*	*D*	*M*	*D*	*M*	*D*	*M*	*D*	*M*
31	33	26	32	39	31	51	31	04	30	15	29	27	28	39
32	33	02	32	16	31	28	30	42	29	54	29	06	28	19
33	32	38	31	53	31	05	30	19	29	32	28	45	27	58
34	32	13	31	27	30	41	29	56	29	10	28	24	27	37
35	31	47	31	02	30	17	29	33	28	47	28	02	27	16
36	31	21	30	37	29	53	29	09	28	24	27	39	26	54
37	30	54	30	11	29	27	28	41	28	00	27	16	26	32
38	30	26	29	44	29	01	28	19	27	35	26	52	26	09
39	29	58	29	17	28	35	27	53	27	11	26	28	25	46
40	29	30	28	50	28	09	27	27	26	46	26	04	25	22
41	29	02	28	22	27	41	27	01	26	20	25	39	24	58
42	28	32	27	54	27	14	26	34	25	54	25	14	24	34
43	28	03	27	24	26	46	26	07	25	27	24	48	24	08
44	27	32	26	55	26	17	25	39	25	00	24	22	23	43
45	27	02	26	26	25	48	25	11	24	34	23	56	23	18
46	26	32	25	56	25	19	24	43	24	06	23	29	22	52
47	26	00	25	25	24	50	24	14	23	38	23	01	22	26
48	25	29	24	55	24	20	23	45	23	10	22	34	21	59
49	24	57	24	23	23	49	23	15	22	41	22	06	21	31
50	24	25	23	52	22	19	22	46	22	12	21	38	21	04
51	23	52	23	20	22	48	22	16	21	42	21	10	20	37
52	23	19	22	48	22	16	21	45	21	13	20	41	20	08
53	22	46	22	16	21	45	21	14	20	43	20	12	19	40
54	22	12	21	43	21	13	20	43	20	13	19	42	29	11
55	21	38	21	10	20	46	20	12	19	42	19	13	18	43
56	21	04	20	37	20	08	19	40	19	11	18	43	18	14
57	20	30	20	03	19	35	19	08	18	40	18	12	17	44
58	19	55	19	29	19	02	18	36	18	09	17	42	17	14
59	19	20	18	55	18	29	18	03	17	37	17	11	16	44
60	18	45	18	20	17	56	17	31	17	05	16	40	16	14

A Table *of the Stiles height.*

Degrees of Latitude.

Degrees	50		51		52		53		54		55		56	
	D	*M*	*D*	*M*	*D*	*M*	*D*	*M*	*D*	*M*	*D*	*M*	*D*	*M*
61	18	10	17	46	17	22	16	58	16	34	16	11	15	14
62	17	34	17	11	16	48	16	25	16	01	15	38	15	13
63	16	58	16	36	16	14	15	52	15	29	15	06	14	43
64	16	22	16	01	15	40	15	18	14	56	14	34	14	11
65	15	46	15	29	15	05	14	44	14	23	14	02	13	40
66	15	10	14	50	14	30	14	10	13	50	13	29	13	09
67	14	33	14	14	13	55	13	36	13	17	12	57	12	37
68	13	56	13	38	13	20	13	02	12	43	12	25	12	06
69	13	19	13	02	12	45	12	27	12	10	11	52	11	34
70	12	42	12	26	12	09	11	53	11	36	11	19	11	02
71	12	05	12	06	11	33	11	18	11	02	10	46	10	29
72	11	28	11	13	10	58	10	43	10	28	10	13	09	57
73	10	50	10	36	10	22	10	08	09	54	09	39	09	25
74	10	12	10	00	09	46	09	33	09	19	09	06	08	52
75	09	35	09	22	09	10	08	58	08	45	08	32	08	19
76	08	57	08	45	08	34	08	23	08	10	07	59	07	47
77	08	19	08	08	07	58	07	47	07	36	07	25	07	14
78	07	41	07	31	07	21	07	11	07	01	06	51	06	41
79	07	03	06	54	06	45	06	36	06	26	06	17	06	07
80	06	25	06	16	06	09	05	00	05	52	05	43	05	34
81	05	46	05	39	05	32	05	24	05	16	05	09	05	01
82	05	07	05	01	04	54	04	48	04	41	04	34	04	27
83	04	30	04	24	04	18	04	12	04	06	04	08	03	54
84	03	51	03	46	03	41	03	38	03	31	03	26	03	21
85	03	13	03	09	03	05	03	01	02	56	02	52	02	48
86	02	34	02	31	02	28	02	25	02	21	02	18	02	14
87	01	56	01	53	01	51	01	48	01	46	01	43	01	41
88	01	17	01	16	01	14	01	12	01	11	01	09	01	07
89	00	39	00	38	00	37	00	36	00	35	00	34	00	33
90	00	00	00	00	00	00	00	00	00	00	00	00	00	00

The use of the preceding and following Tables, the one shewing the Height of the Stile, the other the Inclination of Meridians for Vertical decliners, to every degree of declination, and from 50 to 56 degrees of Latitude.

The use that is to be made of the first Table is to find the Heighth of the Stile above the Substile for every degree of Declination, for 7 Latitudes, as thus. Find first the degree of Declination in the first Columne, and just against it under the Latitude, you have the Height of the Stile. *Example*, declination 30, Latitude 53, Height of Stile 31. 25.

The use of the second Table is to find the Inclination of Meridians the same way. *Example*, Declination 30, Latitude 53, Inclination of Meridians 35. 51, and so if there be any odde minutes in the Latitude or Declination, reason will direct yon in using the proportionall part to find your desire, for those two requisites, and then your Diall is sodainly made.

I was the more willing to calculate these two Tables, because Vertical Decliners are the most usual Dials next to the Horizontal.

The proportion for these two Requisites, you have in the 2. Section of the 14 Chapter.

A Table *of the Inclination of Meridians.*

Degrees of Latitude.

Declina	50		51		52		53		54		55		56	
	D	M	D	M	D	M	D	M	D	M	D	M	D	M
1	01	18	01	17	01	16	01	15	01	14	01	13	01	22
2	02	36	02	34	02	32	02	30	02	28	02	26	02	25
3	03	55	03	51	03	48	03	45	03	42	03	39	03	37
4	05	13	05	09	05	04	05	00	04	56	04	53	04	49
5	06	31	06	25	06	20	06	15	06	10	06	06	06	02
6	07	49	07	42	07	36	07	30	07	24	07	19	07	13
7	09	06	08	58	08	51	08	44	08	38	08	31	08	25
8	10	24	10	15	10	07	09	59	09	51	09	44	09	37
9	11	41	11	31	11	22	11	53	11	04	10	56	10	49
10	12	57	12	47	12	37	12	27	12	18	12	09	12	00
11	14	14	14	02	13	51	13	40	13	30	13	21	13	21
12	15	30	15	28	15	06	14	54	14	43	14	33	14	23
13	16	46	16	33	16	20	16	07	15	55	15	24	15	34
14	18	02	17	48	17	34	17	21	17	08	16	56	16	45
15	19	16	19	01	18	47	18	32	18	19	18	06	17	54
16	20	31	20	15	20	00	19	45	19	31	19	17	19	05
17	21	45	21	28	21	12	20	56	20	42	20	28	20	24
18	22	59	22	41	22	25	22	08	21	53	21	38	21	24
19	24	12	23	54	23	36	23	19	23	03	22	48	22	33
20	25	25	25	06	24	47	24	30	24	13	23	57	23	42
21	26	37	26	17	25	58	25	40	25	23	25	06	24	51
22	27	48	27	28	27	09	26	50	26	32	26	15	25	59
23	28	59	28	38	28	18	27	59	27	47	27	23	27	06
24	30	10	29	48	29	28	29	08	28	49	28	31	28	14
25	31	20	30	58	30	37	30	17	29	57	29	39	29	21
26	32	29	32	07	31	45	31	25	31	05	30	46	30	20
27	33	37	33	25	32	53	32	32	32	12	31	53	31	34
28	34	46	34	23	34	00	33	39	33	19	32	59	32	47
29	35	53	35	29	35	07	34	45	34	25	34	05	33	40
30	37	00	36	36	36	14	35	51	35	30	35	10	34	51

The use of the preceding and following Tables, the one shewing the Height of the Stile, the other the Inclination of Meridians for Vertical decliners, to every degree of declination, and from 50 to 56 degrees of Latitude.

The use that is to be made of the first Table is to find the Heighth of the Stile above the Substile for every degree of Declination, for 7 Latitudes, as thus. Find first the degree of Declination in the first Columne, and just against it under the Latitude, you have the Height of the Stile. *Example*, declination 30, Latitude 53, Height of Stile 31. 25.

The use of the second Table is to find the Inclination of Meridians the same way. *Example*, Declination 30, Latitude 53, Inclination of Meridians 35. 51, and so if there be any odde minutes in the Latitude or Declination, reason will direct yon in using the proportionall part to find your desire, for those two requisites, and then your Diall is sodainly made.

I was the more willing to calculate these two Tables, because Vertical Decliners are the most usual Dials next to the Horizontal.

The proportion for these two Requisites, you have in the 2. Section of the 14 Chapter.

A Table *of the Inclination of Meridians.*

Degrees of Latitude.

Declina	50		51		52		53		54		55		56	
	D	M	D	M	D	M	D	M	D	M	D	M	D	M
1	01	18	01	17	01	16	01	15	01	14	01	13	01	22
2	02	36	02	34	02	32	02	30	02	28	02	26	02	25
3	03	55	03	51	03	48	03	45	03	42	03	39	03	37
4	05	13	05	09	05	04	05	00	04	56	04	53	04	49
5	06	31	06	25	06	20	06	15	06	10	06	06	06	02
6	07	49	07	42	07	36	07	30	07	24	07	19	07	13
7	09	06	08	58	08	51	08	44	08	38	08	31	08	25
8	10	24	10	15	10	07	09	59	09	51	09	44	09	37
9	11	41	11	31	11	22	11	53	11	04	10	56	10	49
10	12	57	12	47	12	37	12	27	12	18	12	09	12	00
11	14	14	14	02	13	51	13	40	13	30	13	21	13	21
12	15	30	15	28	15	06	14	54	14	43	14	33	14	23
13	16	46	16	33	16	20	16	07	15	55	15	24	15	34
14	18	02	17	48	17	34	17	21	17	08	16	56	16	45
15	19	16	19	01	18	47	18	32	18	19	18	06	17	54
16	20	31	20	15	20	00	19	45	19	31	19	17	19	05
17	21	45	21	28	21	12	20	56	20	42	20	28	20	24
18	22	59	22	41	22	25	22	08	21	53	21	38	21	24
19	24	12	23	54	23	36	23	19	23	03	22	48	22	33
20	25	25	25	06	24	47	24	30	24	13	23	57	23	42
21	26	37	26	17	25	58	25	40	25	23	25	06	24	51
22	27	48	27	28	27	09	26	50	26	32	26	15	25	59
23	28	59	28	38	28	18	27	59	27	47	27	23	27	06
24	30	10	29	48	29	28	29	08	28	49	28	31	28	14
25	31	20	30	58	30	37	30	17	29	57	29	39	29	21
26	32	29	32	07	31	45	31	25	31	05	32	46	30	20
27	33	37	33	25	32	53	32	32	32	12	31	53	31	34
28	34	46	34	23	34	00	33	39	33	19	32	59	32	40
29	35	53	35	29	35	07	34	45	34	25	34	05	33	40
30	37	00	36	36	36	14	35	51	35	30	35	10	34	51

A Table *of the Inclination of Meridians.*

Degrees of Latitude.

Declina	50		51		52		53		54		55		56	
	D	M	D	M	D	M	D	M	D	M	D	M	D	M
31	38	06	37	42	37	20	36	57	36	36	36	15	35	56
32	39	12	38	48	38	25	38	02	37	41	37	20	37	00
33	40	17	39	53	39	29	39	07	38	45	38	24	38	04
34	41	21	40	57	40	34	40	11	39	49	39	28	39	08
35	42	25	42	01	41	37	41	14	40	52	40	31	40	11
36	43	28	43	04	42	40	42	17	41	55	41	34	41	13
37	44	31	44	07	43	43	43	20	42	58	42	36	42	16
38	45	34	45	09	44	45	44	22	44	00	43	38	43	18
39	46	56	46	11	45	47	45	24	44	59	44	40	44	20
40	47	36	47	11	46	48	46	25	46	02	45	41	45	20
41	48	37	48	12	47	49	47	25	47	02	46	42	46	21
42	49	36	49	12	48	48	48	25	48	02	47	42	47	21
43	50	36	50	12	49	48	49	25	49	03	48	42	48	22
44	51	34	51	10	50	47	50	24	50	02	49	41	49	21
45	52	32	52	09	51	46	51	23	51	01	50	40	50	20
46	53	30	53	07	52	44	52	21	52	00	51	39	51	19
47	54	27	54	04	53	41	53	19	52	58	52	37	52	17
48	55	24	55	01	54	39	54	17	53	56	53	35	53	16
49	56	20	55	57	55	35	55	13	54	52	54	32	54	13
50	57	16	56	53	56	32	56	10	55	50	55	30	55	10
51	58	11	57	49	57	27	57	06	56	46	56	26	56	07
52	59	06	58	44	58	23	58	02	57	42	57	23	57	04
53	60	00	59	39	59	18	58	57	58	38	58	19	58	00
54	60	54	60	33	60	12	59	52	59	33	59	14	58	56
55	61	47	61	27	61	07	60	47	60	28	60	10	59	52
56	62	40	62	20	62	00	61	41	61	22	61	05	60	47
57	63	33	63	13	62	54	62	35	62	17	61	59	61	42
58	64	25	64	06	63	47	63	28	63	11	62	54	62	37
59	65	17	64	58	64	40	64	22	64	04	63	47	63	31
60	66	08	65	50	65	32	65	15	64	58	64	41	64	25

A Table of the Inclination of Meridians.

Degrees of Latitude.

Declina	50		51		52		53		54		55		56	
	D	M	D	M	D	M	D	M	D	M	D	M	D	M
61	66	59	66	41	66	24	66	07	65	50	65	34	65	19
62	67	50	67	33	67	16	67	00	66	43	66	28	66	13
63	68	40	68	24	68	07	67	51	67	39	67	20	67	06
64	69	30	69	14	68	59	68	49	68	28	68	13	67	59
65	70	20	70	05	69	50	69	34	69	20	69	05	68	52
66	71	10	70	55	70	40	30	25	70	11	69	58	66	44
67	71	59	71	44	71	30	71	16	71	02	70	49	70	36
68	72	48	72	34	72	20	72	07	71	54	71	41	71	29
69	73	36	73	23	73	10	72	57	72	45	72	32	72	21
70	74	25	74	12	74	00	73	07	73	35	73	24	73	12
71	75	13	75	01	74	49	74	37	74	26	74	15	74	04
72	76	01	75	49	75	38	75	27	75	16	75	06	75	15
73	76	49	76	38	76	27	76	17	76	06	75	56	75	47
74	77	36	77	26	77	16	77	06	76	56	76	47	76	37
75	78	24	78	14	78	05	77	55	77	46	77	40	77	28
76	79	11	79	02	78	53	78	44	78	36	78	27	78	19
77	79	58	79	50	79	41	79	33	79	25	79	17	79	10
78	80	45	80	37	80	29	80	21	80	14	80	08	80	00
79	81	31	81	23	81	17	81	10	81	04	80	57	80	51
80	82	18	82	12	82	05	81	59	81	53	81	47	81	41
81	83	05	82	59	82	53	82	47	82	42	82	36	82	31
82	83	51	83	46	83	41	83	35	83	31	83	26	83	21
83	84	38	84	33	84	28	84	24	84	19	84	15	84	11
84	85	24	85	20	85	16	85	12	85	08	85	05	85	02
85	86	10	86	06	86	03	86	00	85	57	85	54	85	51
86	86	56	86	53	86	51	86	48	86	46	86	43	86	41
87	87	42	87	40	87	38	87	36	87	34	87	32	87	31
88	88	28	88	27	88	26	88	24	88	23	88	22	88	24
89	89	14	89	13	89	13	89	12	49	11	89	11	89	10
90	90	00	90	00	90	00	90	00	90	00	90	00	90	00

The use of the two following Tables, the one shewing the Altitude, the other the Azimuth of the Sun, at every houre, halfe and quarter of houre, in the beginning of each Signe of the Zodiack, in the Latitude of 51 deg. 32 min.

THe uſes that are to be made of the following Tables, are divers, as to finde a Meridian Line on any plain, as alſo for furniſhing of all manner of Dials either Plain, Concave, Convex, Cylindrical or any other Figure (either Regular or Irregular) with ſuch varieties as are often (for curioſity) drawn upon Dials: as the Lignes of the Zodiack, the parallels of the length of the day, the Italian, Babyloniſh and Jeiwiſh hours, the Azimuth of the Sun upon any point of the Chmpaſſe, with many other varieties depending upon the Suns Altitude and Azimuth at all hours..

The Proportions by which theſe Tables were Calculated you ſhall finde in the 26 Chapter.

A Table shewing the Altitude of the Sunn for every Hour, and quarter, at his entrance into each of the 12 Signes of the Zodiack, exactly calculated for the Latitude of London.

51. deg. 32. m.

Hours	♋	♌	♍	♎	♏	♐	♑	♒	♓	♈	♉	♊
	Altitud	Altit	Alti	Alti	Alti	Altit	Altit					
	D M	D M	D M	D M	D M	D M	D M					
XII	61 59	58 41	49 59	38 28	26 57	18 15	14 57					
I	61 49	58 34	49 52	38 22	26 52	18 10	14 52					
2	61 23	58 08	49 32	38 04	26 37	17 56	14 39					
3	60 40	57 27	48 57	37 36	26 12	17 34	14 18					
I. XI	59 42	56 33	48 10	36 56	25 37	17 03	13 48					
I	58 29	55 25	47 11	36 05	24 53	16 24	13 09					
2	57 04	54 06	46 01	35 04	24 01	15 36	12 23					
3	55 29	52 34	44 40	33 55	22 59	14 19	11 29					
II. X	53 45	50 55	43 11	32 36	21 49	13 36	10 28					
I	51 53	49 07	41 32	31 08	20 31	12 24	09 19					
2	49 54	47 12	39 47	29 34	19 06	11 06	08 03					
3	47 51	45 13	37 57	27 53	17 36	09 42	06 41					
III. IX	45 42	43 07	35 59	26 05	15 57	08 11	05 13					
I	43 31	40 58	33 57	24 12	14 13	06 34	03 39					
2	41 16	38 45	31 49	22 15	12 23	04 51	01 59					
3	38 59	36 30	29 40	20 13	10 30	03 05	00 15					
IIII. VIII	36 42	34 14	27 28	18 07	08 32	01 13						
I	34 23	31 56	25 13	15 58	06 31							
2	32 04	29 37	22 56	13 46	04 25							
3	29 43	27 16	20 37	11 32	02 16							
V. VII	27 23	24 56	18 18	09 17	00 05							
I	25 04	22 37	15 59	06 58								
2	22 46	20 17	13 39	04 39								
3	20 28	17 57	11 16	02 20								
VI.	18 12	15 42	09 00									
I	15 58	14 00	06 44									
2	13 46	11 13	04 24									
3	11 37	09 01	02 08									
VII. V	09 30	06 52										
I	07 25	04 46										
2	05 24	02 42										
3	03 27	00 43										
IIII VIII	01 34											

A Table shewing the Azimuth from South, for every Hour, and quarter, at his entrance into each of the 12 Signes of the Zodiack, exactly calculated for the Latitude of London. 51. deg. 32. m.

Hours	♋ Azim		♊ ♌ Azim		♉ ♍ Azim		♈ ♎ Azim		♓ ♏ Azim		♒ ♐ Azim		♑ Azim	
	D	M	D	M	D	M	D	M	D	M	D	M	D	M
XII	000	00	000	00	00	00	00	00	00	00	00	00	00	00
1	07	10	05	53	05	37	04	55	03	54	03	53	03	52
2	14	22	13	24	11	10	09	40	07	57	07	40	07	10
3	21	27	19	53	16	44	14	13	12	11	11	10	10	37
I. XI	27	56	26	00	22	13	18	52	16	22	14	45	14	13
1	34	14	32	01	27	32	23	22	20	15	18	17	17	38
2	40	12	37	40	32	41	27	41	24	06	21	53	20	59
3	45	39	43	04	37	32	32	08	29	44	26	30	24	25
II. X	50	51	47	57	42	05	36	24	31	50	28	52	27	49
1	55	31	52	41	47	04	40	30	35	35	32	18	31	00
2	61	43	57	11	50	51	44	26	39	10	35	39	34	17
3	64	11	41	18	54	33	48	13	42	36	38	50	37	34
III. IX	68	10	65	16	58	47	51	56	46	02	42	04	40	38
1	71	52	69	56	62	33	55	33	49	25	45	16	43	40
2	75	36	72	37	66	10	58	59	52	43	48	21	46	42
3	78	48	76	05	69	38	62	22	55	59	51	21	49	40
IIII. VIII	82	00	79	20	72	57	65	40	59	00	54	22		
1	85	08	82	42	76	12	68	53	62	08				
2	88	10	85	38	79	23	72	06	65	12				
3	91	09	87	50	82	28	75	07	68	12				
V. VII	94	15	91	34	85	30	78	06	71	10				
1	96	51	94	25	88	27	81	09						
2	99	38	97	16	91	23	84	06						
3	102	25	100	07	94	22	87	04						
VI.	105	08	102	54	97	12								
1	107	52	104	58	100	02								
2	110	36	108	26	103	00								
3	113	18	111	14	105	54								
VII. V	116	03	114	03										
1	118	50	116	54										
2	121	41	119	47										
3	124	29	122	37										
III VIII.	127	24												

A Table shewing the Latitude of the principall Cities and Towns in Great-Brittain & Ireland.

Names of Places			*Latitude* D.	M.	*Names of Places*			*Latitude* D.	M.
St. Albons			51	55	Caterlagh	}		52	41
Anglesey	W		53	28	Clare	}	I	52	34
Antrim	}		54	38	Cork	}		51	53
Anglas	}	I	54	10	Derby			53	06
Armagh	}		54	14	Dorchester			50	40
St. Andrews	}		56	39	Durham			54	50
	}	S			Denby	}		53	13
Aberdean	}		57	32		}	W		
Barwick			55	49	St. Davids	}		52	0
Bedford			52	18	Danblain	}		56	21
Bristol			51	32		}	S	56	48
Boston			53	2	Dunkel	}			
Buckingham			52	00	Croghedah	}		53	38
Barmouch	}		52	50	Dublin	}	I	53	13
	}	W			Dundalk	}		53	52
Breeknock	}		52	1	Exon			50	40
Cambridge			52	17	Edenburgh	S		55	56
Chester			53	20	Flint	W		53	17
Coventry			52	30	Grantham			52	58
Chichester			50	56	Gilford			51	12
Colchester			52	4	Gloceſter			51	53
Canterbury			51	17	Gernzey Isle			49	30
Carlisle			55	0	Glascow	S		55	52
Cardegan	}		52	12	Galloway	I		53	0
Carmarthen	}	W	51	56	Halifax			53	49
Carnarvan			53	16	Hereford			52	14

Names of Places	Latitude D.	M.
Hull	53	50
Hartford	51	49
Huntington	52	19
Ipſwich	52	8
Jerſey Iſland	49	12
Kendall	54	48
Kilkenny	52	27
Kildare	53	0
Kings Town I	53	8
Knockfergus	54	37
Kinſale	51	41
Launſton	50	41
London	51	32
Lancaſter	54	8
Leiceſter	52	40
Lincolne	53	15
Landalfe W	51	35
Lundy Iſle	51	22
Lymerick I	52	30
Man Iſle	54	24
Monmouth W	51	51
Montgomer W	51	56
Newcaſtle	54	58
Northampton	52	14
Norwich	52	42
Nottingham	53	0
Oxford	51	46
Orkney Iſle S	60	6
Penbrooke W	51	46
Portland Iſle	50	33
Queens Town I	52	52
Reading	51	28
Radnor W	52	19
Shrewsbury	52	48
Salusbury	51	4
Stafford	52	52
Stamford	52	38
Skiraſtin S	58	36
Sterling S	56	12
Truero	50	30
Warwick	52	26
Winchelter	51	3
Worceſter	52	14
Wight Iſland	50	39
Waterford I	52	9
Wexford I	52	18
Yarmouth	52	45
York	54	0
Youghall I	51	53

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AN APPENDIX:

Shewing how to resolve the most usuall Questions in *Astronomie*, *Navigation* and *Geography*, by the Diagonal Scales, and Scales of *Sines* and *Tangents* on the Ruler.

CHAP. I.

How to resolve divers usefull Questions in Astronomie, *by means of the Diagonall Scales, and the Scales of* Sines *and* Tangents *together, for the Latitudes of* 50, 51, 53, 54, 55, 56.

PROP. I.

The Latitude of the place, 50 deg. *Declination of the Sun* 20 deg. *being given, to finde the* Amplitude.

With your Compasses extended from the beginning of the parallel of 50, on the first Scale, (known by the letters *Sil. Vir.*) to the declination 20, and that extent being applied to the Scale of Sines, will give you the Amplitude of the Suns rising or setting from the East or West points 32 9. and note, that this amplitude is always North when the Sunne is in the Northern

Huntington		52	19	Orkney Isle	S 60 6
Ipswich		52	8	Penbrooke	W 51 46
Jersey Island		49	12	Portland Isle	50 33
Kendall		54	48	Queens Town	I 52 52
Kilkenny		52	27	Reading	51 28
Kildare		53	0	Radnor	W 52 19
Kings Town	I	53	8	Shrewsbury	52 48
Knoekfergus		54	37	Salusbury	51 4
Kinsale		51	41	Stafford	52 52
Launston		50	41	Stamford	52 38
London		51	32	Skiraftin	S 58 36
Lancaster		54	8	Sterling	S 56 12
Leicester		52	40	Truero	50 30
Lincolne		53	15	Warwick	52 26
Landalfe	W	51	35	Winchelter	51 3
Lundy Isle		51	22	Worceſter	52 14
Lymerick	I	52	30	Wight Island	50 39
Man Isle		54	24	Waterford	I 52 9
Monmouth	W	51	51	Wexford	I 52 18
Montgomer	W	51	56	Yarmouth	52 45
Newcastle		54	58	York	54 0
Northampton		52	14	Youghall	I 51 53
Norwich		52	42		

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AN ATTENDIX.

Shewing how to resolve the most usuall Questions in *Astronomie*, *Navigation* and *Geography*, by the Diagonal Scales, and Scales of *Sines* and *Tangents* on the Ruler.

CHAP. I.

How to resolve divers usefull Queflions in Astronomie, *by means of the Diagonall Scales, and the Scales of* Sines *and* Tangents *together, for the Latitudes of* 50, 51, 53, 54, 55, 56.

PROP. I.

The Latitude of the place, 50 deg. *Declination of the Sun* 20 deg. *being given, to finde the* Amplitude.

WIth your Compasses extended from the beginning of the parallel of 50, on the first Scale, (known by the letters *Stil. Ver.*) to the declination 20, and that extent being applyed to the Scale of Sines, will give you the Amplitude of the Suns rising or setting from the East or West points 32 9. and note, that this amplitude is alwayes North when the Suns in the Northern

thern Signes ♈ ♉ ♊ ♋ ♌ ♍, and South when the Sun is in southerns ignes ♎ ♏ ♐ ♑ ♒ ♓.

PROP. 2.

The Latitude 50 *and the Amplitude* 32,9 *being given to finde the declination.*

Extend your Compasses from the beginning of the Sines to the sine of the amplitude, and apply that extent, to the parallel of 50. on the first Diagonall Scale, and it will reach to the declination 20 deg.

PROP. 3.

The Suns amplitude 32 *deg.* 9 *m, and the declinntion* 20 *being given, to finde the Latitude.*

Take out the Sine of the amplitude 32,9 and with one Foote of the compasses so placed in 20 deg. of declination of such one of the parallels, of the first Diagonall, as that the other, may just touch the beginning of the parallel, and that parallel shews the Latitude to be 50.

PROP. 4.

The Latitude 50 *and declination* 20 *being given, to finde the Suns altitude in the Verticall circle, or when he shall come to be due East, or West.*

Take the declination 20 out of the third Diagonall Scale (known by the letters *stile Mer*) and apply it to the Scale of sines and it will give you the altitude 26.31.

PROP. 5.

The Latitude 50. *and Declination* 20 *being given, to finde what altitude the Sun will have at the houre of six.*

Take out the sine of the Declination 20, and measure it

tin the same third Diagonall scale, and it will reach to he altitude 15. 12, on the parallel of 50.

t

PROP. 6.

The Latitude 50. and declination 20. being given to finde what Azimuth the Sun shall have at the houre of six.

Take out the Tangent of the Declination, 20, and measure it in the first Diagonall Scale and parallel of 50. and it will give you the Azimuth from the East or West, points North-ward, 13 10,

PROP. 7.

The Latitude 50 and the Declination 20 being given, to finde the Ascentionall difference.

Take out the Tangent of Declination 20 and measure it in the second Diagonall scale, (known by the letters *Incl. vert.*) and parallel of 50, and it will give the assensionall difference, 25. 43.

Note that when the Suns declination is North, adde it to 90 deg. and it gives the Semidiurnall arch, or time of Sun setting, as in this example the assentionall difference, being 25. 43 which converted into time makes one houre 43. min. and being added to 90 deg. or 6 houres, makes 7 houres 43 min. for the semidiurnall arch, or time of Sun setting, which doubled makes 15 hours 26 min. for the diurnall arch, and being substracted out of 24 houres leaves 8 hours 34 min. for the Nocturnall arch, whose half 4 hours 17 min. is the time of the Suns rising. But if the declination be South substract one houre 43 min. out of 6 houres rest 4 houres 17 min. for the semidiurnall arch, which doubled makes 8 houres 34 m. for the length of the day whose compliment to 24 houres to wit 15 houres 26 min. gives the length of the night and whose half 7 hours 43 min. gives the time of Sun rising.

CHAP.

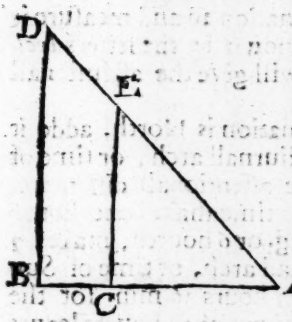
CHAP. II.

How to resolve questions in Astronomie, by the Lines of Sines and Tangents on the Ruler, for all Latitudes.

PROP. 1.

The length of a Gnomon set perpendicular to the Horizon, and the length of its shadow being given, to finde the Suns altitude.

Suppose the Gnomon to be 12 parts, and the shadow 9. Draw the rectangle D B A according to the direction of the second section of the 14 chapter, make A B equall to any 12 equall parts, and A C equall to 9 of the same equall parts, and draw C E parallel to B D and equall to the Radius, then draw A E and prolonge it to cut the line B D in D, so B D being measured on your Tangent scale, will appear to be 53 deg. 8 minutes the Suns altitude required.



Note that as to the following propositions, I shall for brevity sake, mention only the proportion in reference to the schem.

PROP. 2.

The length of a Gnomon standing at right angles with any perpendicular Wall, and parallel to the Horizon, together with the length of the shadow, being given, to finde the Suns Altitude.

As *A B* 12 parts, is to *A C* 9 parts: So is *B D* radius, to *C E* the tangent of 36 5, the altitude required

PROP. 3.

The Suns altitude being given, and the length of the Gnomon, to finde the length of Right shadow.

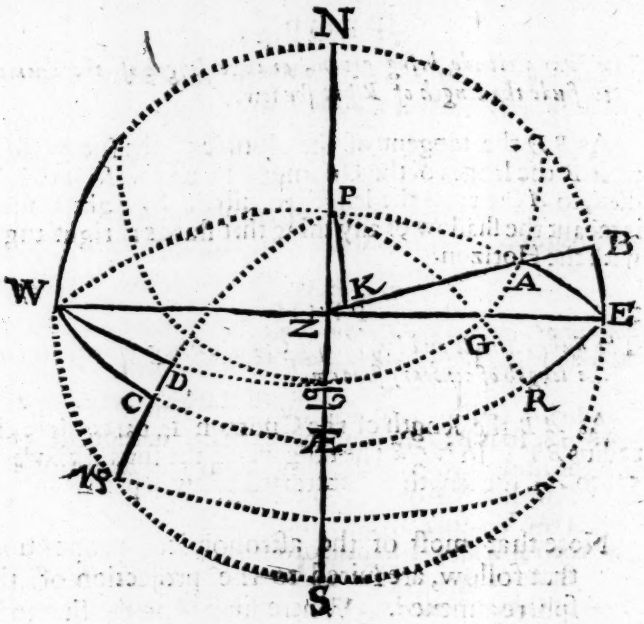
As *B D* the tangent of the altitude of the sun 53 8, is to *A B* the length of the Gnomon, 12 parts, so is *C E* radius, to *A C* 9 parts the length required. By right shadow is meant the shadow of any thing that stands at right angles with the Horizon.

PROP 4.

The Suns altitude and length of a Gnomon being given, to finde the length of contrary shadow.

As *A B* the length of the Gnomon 12 parts, is to the radius *B D*, so is *C E* the tangent of the suns altitude 36 52, to *A C* the length of contrary shadow, 9 parts.

Note that most of the astronomicall propositions that follow, are suited to the projection of the sphere annexed. Where supposing the Sun to be in the beginning of *Taurus* 30. deg. from *Aries*: W D is a portion of the Ecliptick, W C part of the Equator, and D C part of the circle of declination, falling at right angles on the Equator in the point C. P G R a Meridian, cutting the Prime Vertical at its intersection with the Tropick of *Cancer*. W P E, the Houre-circle of 6. And Z A B an Azimuth passing through the intersection of the Tropick of *Cancer*, and Houre-circle of 6.



PROP. 5.

The Suns distance from the next Æquinoctial point 30 degrees being given, to finde his Declination.

Suppose the sun to be in 00 degrees of *Taurus*, the distance from *Aries* is 30 degrees, so the proportion is,

As *A B* radius, is to *A C* the sine of the suns greatest declination 23 31, so is *B D* the sine of the distance 30, to *C E* the sine of the declination required, 11 31, answering to the side D C of the Projection.

PROP.

PROP. 6.

The Latitude of the place 51 32, *and the Suns declination* 23 31, *being given, to finde the Amplitude.*

As *A B* the cosine of the Latitude 38. 28, is to *A C* the sine of declination, 23 31, so is *B D* radius, to *C E* the sine of 39 54, the amplitude required agreeable to the side W ♈ in the projection.

PROP. 7.

The Latitude 51 32. *and Declination* 23 31, *being given, to find the time when the Sun will be due East, or West.*

1 As *A B* radius, is to *A C* the cotangent of the latitude 38 28, so is B D the tangent of the declination 23 31 to C E the sine of 20 15', the time from the houre of 6 equall to the side R E of the projection.

2 But if the Latitude be lesse then 45, as suppose it to be 38 28 then work by this proportion.

As A B the tangent of the Latitude 38 28, is to A C, the tangent of the declination 23 31, so is B D radius to C E the sine of 33 13, the time from 6.

PROP. 8.

The Latitude 51 32, *and declination* 23 31, *being given, to finde the Suns height in the verticall circle, or when he comes to be due East, or West.*

As A B the sine of the Latitude 51 32, is to A C the sine of the Declination 23 31, so is B D radius, to C E the sine of the Suns hight, required 30 40, equall to the side G E of the projection.

PROP.

PROP. 9.

The Latitude 51 32, *and declination*, 23 31, *being given*, *to finde the Suns altitude, at the houre of six.*

As A B radius, is to A C sine of declination, 23 31, so is B D the sine of the Latitude 51 32, to C E the Suns altitude required 18 12, equall to the side A B of the projection.

PROP. 10.

The Latitude 51 32, *and Declination* 23 31, *being given*, *to finde what Azimuth the Sun will have at the houre of six*,

As A B radius, is to A C Cosine of Lattitude 38 28, so is B D the tangent of declination, 23 13, to C E tangent of the azimuth required 15 9, from East or West, Notthward Equall to the arch E B of the projection.

PROP. 11.

The Latitude 51 32. *and declination* 23 31, *being given*, *to finde the assensionall difference.*

1 Say, As A B Cotangent of Latitude 38 28, is to A C tangent of Declination 23 31, so is B D radius, to C E the sine of the assentionall difference required, 33 12, equall to W C, of the projection.

2 Let the Latitude be 51 32, and the declination North, 11 31, the assensionall difference will be found to be 14 deg. 52 minutes.

PROP. 12.

The houre 58 26, *the Suns altitude* 35 *deg. and the declination North* 20 *deg being given, to finde the suns Azimuth:*

As A C the Cosine of the Suns altitude 55, is to A B the Cosine of declination 70, so is E C the sine of the houre 58 26, to D B the azimuth from the South, 77 52,

PROP.

PROP. 13:

The Azmuth 77 52, the Suns altitude 35, and the declination 20 being given, to find the Houre

As AB the Cosine of declination 70, is to A C the Cosine of the Suns altitude 55, so is B D the sine of the azimuth 77 52, to C E the sine of the houre from the Meridian, 58 26, which in time is three houres 54 minutes

PROP. 14:

The suns distance from the next Equinoctiall point being given, to finde his right assension.

1 If the distance be lesse then 45 deg. as in this example where we will suppose the Sun to be in 00 deg. of *Taurus* 30 degrees from *Aries*. Say, As A B radius, is to A C the cosine of the *Suns* greatest declination, 66 29, so is B D Tangent of distance 30, to C E Tangent of Right assension 27 54, equall to the side W C of the projection.

2 But if the distance be more then 45 as here we will suppose the sunne to be in 29 *Taurus*, distante from *Aries* 59. Say, As A C Cosine of the Suns greatest declination 66 29, is to A B radius, so is C E the Cotangent of the distance 31, to D B the Tangent of 33 14, whose complement 56 46, is the right assension required.

PROP. 15.

The suns right assension 27 54, and the assensionall difference 14 52, being given, to finde the Oblique assension or dessension.

If the Sun hath North declination deduct the assensionall difference out of the right assension, the remainder will be the oblique assention, but if you adde them together the summe will be the oblike dessension.

But

But if the declination be South, add the assensionall difference and right assension together, and the summe will be the oblique assension, but substract the one from the other, and the residue will be the oblique desention.

So (making use of the 2 example, of 11 Prop. for the assentionall difference, 14 32, and declination North, 11 31 as also of the 1 example of the 14 proposition, for the Right assention 27 54,) I substract 14 52, from 27 54, rest 13 deg. 2 min. for the oblique assension which being added together, make 42 46, for the oblique desention *et contra*.

To conclude this Chapter, I shall desire the reader once more, to looke back on the projection in refference to Dialling where supposing Z N B to be a declining Plaine, if you crosse it at right angles, with the Meridian, or houre circle P K you have the right angled Sphericall Triangle Z K P to resolve. where P K is 36 54, the stiles highth Z K 11 59, the distance of the Substile, from the Meridian, Z P K 19 5, the angle of Inclination of meridians P Z K 74 51 the complement of declination and P Z 38 28, the complement of the Latitude. This I thought good to insert that the Reader might see, how these kindes of Dialls appear on the Sphere, (whose projection is taught in the 24th Chap. of this Treatise) and he may finde this Scheme Largely discursed off by Mr Wells, *in the 36 Chapter*

Chapter, pag. 410. *of his book* Intituled the Art of Shadows.

Note, that whereas for some of the Propositions aforegoing, as also for others that follow, I have mentioned two several Proportions, the reason is, onely in reference to the tangent scale, which goes but to 64 deg. for if you use the Gunter there will be no need of this caution.

CHAP. III.

How to resolve questions in Navigation, by the Lines of Sines, Tangents and Equal parts.

WHereas in the precedent chapter there was use made onely (saving in the four first propositions) of lines and tangents, now for the resolution of such questions as follow, the scale of equal parts must be added to set off the distances of miles or Leagues. And here it

A Table for reducing of Degrees to Leagues and Miles. *& Contra.*

Deg.	Leag.	Miles	Deg.	Leag	Miles
1	20	60	10	200	600
2	40	120	20	400	1200
3	60	180	30	600	1800
4	80	240	40	800	2400
5	100	300	50	1000	3000
6	120	360	60	1200	3600
7	140	420	70	1400	4200
8	160	480	80	1600	4800
9	180	540	90	1800	5400
10	200	600			

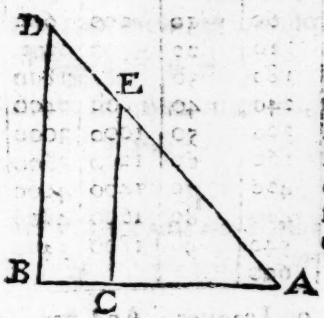
is to be noted, that to the end you may have your figure ſtill of a fitting magnetude; And the lines in a convenient proportion to one another; If any of the given terms be but a ſmall number of Leagues; you may triple them, and then they are reduced to miles, if the term be a great number of miles, take the third part and they are reduced to Leagues, or if the term be a great number of Leagues divide them by 20, and they are reduced to degrees, and for which the Table aforegoing may be of ſome uſe, to which I have added a brief Table of Rumbes, and ſo proceed to the propoſitions.

A Brief Table of Rombes.

Ro.					Angle
1	N. by E.	N. by W.	S. by E.	S. by W.	11. 15
2	N. N. E.	N. N. W.	S. S. E.	S. S. W.	22. 30
3	N. E. by N.	N. W by N.	S. E. by S.	S. W. by S.	33. 45
4	N E.	N. W.	S. E.	S. W.	45. 00
5	N. E. by E.	N. W. by W.	S. E. by E.	S. W. by W.	56. 15
6	E. N. E.	E. S. E.	W. N. W.	W. S. W.	67. 30
7	E. by N.	E. by S.	W. by N.	W. by S.	78. 45
8	East.	West.			90. 00

PROP. I.

The Latitude 48 *being propoſed, to find how many Miles anſwers to one degree of Longitude in that Latitude.*



As A B Radius, is to A C the Coſine of the Latitude, ſo is B D 60 equal parts for miles anſwering one degree at the equator, to C E 40 miles anſwering one degree of the equator in that Latitude.

PROP.

PROP. 2.

The Latitude 48 *being proposed, to find what difference of Longitude belongeth to one degree of distance upon any parallel of Latitude.*

As A C the Cosine of the Latitude 42, is to A B radius, so is C E 60 miles, to B D 90 miles, and so many miles of Longitude belong to one degree of distance on that parallel.

PROP. 3.

The Rombe being proposed, the fifth from the Meridian, whose angle is 56. 15. *to finde how many leagues do answer one degree of Latitude thereon.*

As A C, the Cosine of the rombe 33. 45. is to A B 60 miles; so is C E Radius, to B D 108 miles, which reduced, makes 36 Leagues, and so many Leagues answer to one degree of Latitude on that Rombe.

PROP. 4.

The Rombe 56. 15. *and Leagues sailed* 72 *being given, to find the difference of Latitude, or how much a ship hath raised or depressed the pole.*

As A B radius, is to A C the cosine of the Rombe 33. 45, so is B D 72 the distance run, to C E 40 leagues, or 2 deg. and so much hath the ship raised or depressed the pole to be added to, or substracted from, the Latitude from which she departed.

PROP. 5.

The Rombe 56. 15, *and both Latitudes* 48 *and* 50 *being given, to finde the distance run on that rombe.*

As A C the cosine of the rombe 33. 45, is to A B Radius,

so is C E the difference of Latitudes 40 Leagues, to B D 72 the distance run on that rombe.

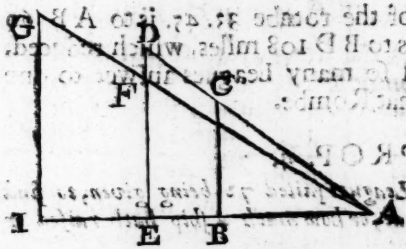
PROP. 6.

The distance run 72, and both Latitudes 48 and 50 being given, to finde the Rombe.

As A B the distance run, is to A C the difference of latitudes 40 Leagues, so is B D Radius, to C E the sine of 33. 45 the Cosine of the rombe required.

PROP. 7.

The Rombe 56. 15 and both Latitudes 48 and 50 being given, to find the difference of Longitude.

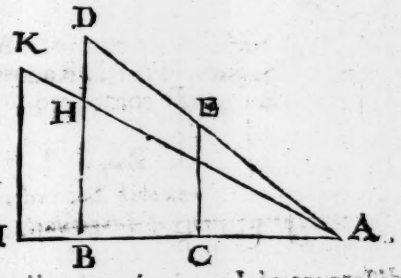


As B C the cosine of the rombe 33. 45, is to A B the difference of Latitudes 40 League, so is D E the sine of the Rombe 56. 15, to E A the difference of longitude in the common Sea chart 60, then find the middle latitude (which is halt the difference of the 2 latitudes added to the lesser, or subtracted from the greater latitude) to wit 49 deg. Then say, As E F the cosine of the middle latitude 41, is to G I Radius, so is E A 60, to A I the difference of longitude required, 91 leagues $\frac{1}{4}$.

PROP.

PROP. 8.

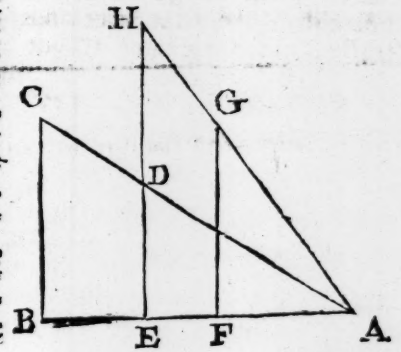
The difference of Latitudes 40 Leagues, and the Leagues sailed 72 being given, to find the difference of Longitude.



As AB the distance sailed 72, is to AC the difference of latitudes 40, so is BD radius, to CE the cosine of the rombe 33. 45. Then As BH the cosine of the middle latitude 41. is to BA the distance sailed 72, so is KI the sine of the rombe 56. 15. to AI the difference of longitude 91 ¼.

PROP. 9.

The difference of Latitude 40, and difference of Longitude 91 ¼ being given, to finde the Rombe leading from the one to the other.

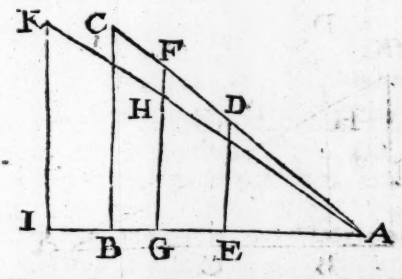


As BC radius, is to AB the difference of longitude. So is DE the cosine of the middle latitude 41. to EA 60, the difference of longitude according to the common Sea Chart. Then, As AF the difference of latitudes 40, is to AE 60, so is FG radius, to EH the tangent of the rombe 56. 15.

PROP.

PROP. 10.

By one Latitude 50 the Rombe 56.15. and distance sailed 72 Leagues, to find the difference of Latitude and also of Longitude.



As BC Radius, is to AB the distance run 72, so is DE the cosine of the rombe 33. 45, to EA, the difference of Latitudes 40.

Then as DE fine of 33. 45, is to EA 40, so is FG the fine of the rombe 56. 15, to GA difference of Longitude according to the common Sea-chart 60.

Lastly, As HG the cosine of the middle Lat. 41. is to GA 60; so is KI radius, to AI the difference of Longitudes 91 $\frac{1}{4}$.

CHAP.

CHAP. IV.

How to resolve questions in Geography by the lines of Sines, Tangents, and equal parts.

PROP. 1.

Two places being given which differ only in latitude, to find their distance.

1. When the two places are situate under the same meridian, and on the same side of the equinoctial, substract the lesser ont of the greater latitude, and the remainer is the distance.

Example, let one of the places have 10 degrees of North or South Latitude, and the other 30, the residue is 20, which being reduced by the Table, gives 400 leagues or 1200 miles the distance required: equal to the arch A B of the projection.

2. When both places are under one and the same Meridian, but the one hath North, and the other South latitude, then adde them together, and the summe is the distance.

Example, let one place have 10 deg. of North, and the other 30 deg. of South lat. the summe is 40 deg. which reduced by the Table, makes 800 leagues, or 2400 miles the distance required: equal to the arch A C of the projection.

PROP. 2.

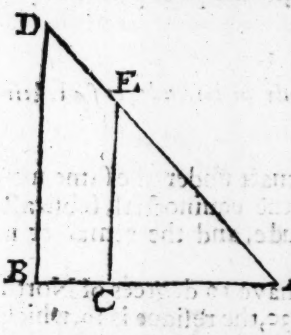
Two places which differ onely in longitude being given, to find their distance.

1. When the places are situate both of them under the Equinoctial, substract the lesser longitude from the greater, and the remainer is the distrnce.

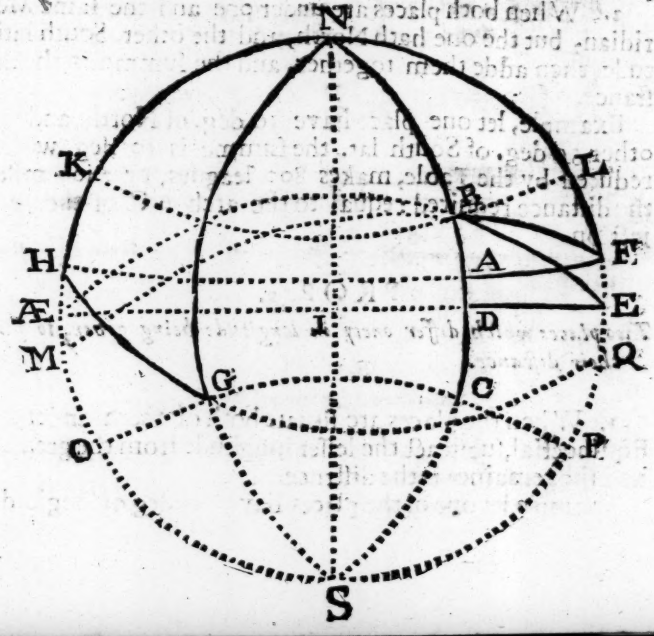
Example, let one of the places have 145 deg. of longitude,

and

and the other 180, the residue is 35, which reduced gives 700 leagues or 2100 miles for the distance required, equal to the arch D E of the projection.



2. When the two places lie under some parallel between the equinoctial, and one of the poles, as suppose both places to have North lat. 10 deg. and let their difference of longitude be 35. Say As A B radius, is to A C the cosine of the common latitude 10, so is B D the sine of half the difference of longitude 17. 30, to C E the line of 12, 14, which being doubled makes 24. 28, which being reduced makes 489 Leagues 1 Mile, or 1468 miles, the distance required equal to the arch A F of the projection.



An Explanation of the Projection in reference to the foregoing and following Propositions.

N H S E, The first Meridian, passing through the Azores.

Æ E The Equator.

N The North } Poles.
S The South }

Æ B E }
M B F } Three Circles of Position.
H G Q }

K B L }
H A F } Parallels of Latitude { 30 } North.
O G P } { 10 } { 30 } South.

N G S } *Meridians* cutting { 35 } Degrees of *Longitude*.
N D S } the Equinoctiall in { 145 }

A B } Resolves the { First } Example of the first Proposition.
A C } { Second }

D E } Resolves the { First } Example of the second Proposition.
A F } { Second }

The Arcs

B E The Base of the Right-Angled Spherical Triangle B D E, Resolves a Case of the nature of the first Example of the third Proposition.

B F The lesser side of the oblique Spherical Triangle F B N, Resolves a Case of the nature of the second Example of the third Proposition.

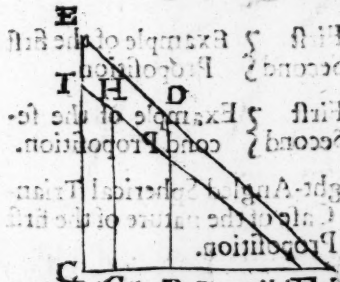
H G The lesser side of the oblique Spherical Triangle G H N, Resolves the third example of the third Proposition.

PROP. 3.

Two places being given, that differ both in Longitude and Latitude, to finde their distance.

1. When one of the places is situate under the Equinoctial, and the other towards one of the Poles, as for example, let one of the places, under the equator, have 73. 36 of Longitude, and the other place have 20 degrees Latitude, and 26: 46 Longitude, their difference of Longitude is 46. 50. *Say*, As A B Radius, is to A C, the cosine of the difference of Longitude 43, 10, so is B D, the Cosine of the Latitude 70, to *C E*, the sine of 40 degrees, which reduced by the Table, gives 800 leagues, or 2400 *Miles* the distance required.

2. When both places are without the equinoctiall, and towards one of the Poles, as for example, let one of the places have 80 degrees of latitude, and the other 46. 30. and let their difference of longitude be 50 degrees. Note, that this following Proportion is to be observed, when the lesser latitude is more then 45 degrees. As *A C* Radius, is to *A B*, the Cosine of the difference of longitude 40; so is *C E*, the Cotangent of the lesser latitude 43. 30 to B D, the Tangent of 31. 50, which being compared with the complement of the greater latitude, to wit, 10; the difference will be found 21. 50. Then say, as F G, the cosine of 31. 50. to wit, 58. 10, is to cosine of 21. 50, to wit, F E, 68. 10. so is G H the sine of the lesser latitude 46, 30 I, the sine of



of 51. 49, whose complement 38. 11 being reduced, gives 763 leagues, and 2 miles, or 2291 miles for the distance required.

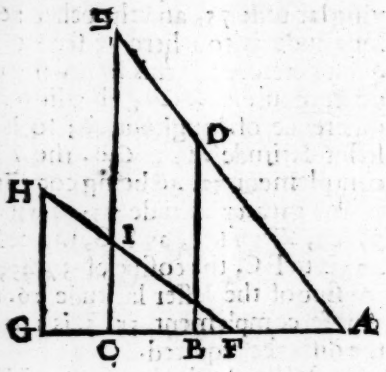
A second example shall be of two places, the one having latitude 75, and the other 26, and whose difference of longitude is 50; here ye see the lesser latitude is less then 45, wherefore use this following proportion with the foregoing figure. As *A C* Radius, is to *A B*, the cosine of the difference of longitude 40; so is B D the Tangent of the lesser latitude 26, to *C E*, the Tangent of 37. 11, whose complement 52. 49 being compared with the complement of the greater latitude 75, to wit 15, the difference will be 37. 49, Then say, as F G, the cosine of 37. 11, to wit, 52. 49, is to F C, the cosine of 37. 49, to wit, 52. 11, so is G H, the sine of the lesser latitude 26. to C I, the sine of 34. 57. whose complement 55. 3, is 1191. leagues, or 3303 miles, the distance required.

3. When both places are without the equinoctiall, the one south, the other north, as for example, let one of the places have 10 degrees of north latitude, and the other 30 degrees of south, and let the difference of longitude be 85, observe whether the latitude you first work with be more or less then 45, and accordingly proceed by the first or second examples of the former section; in this example both latitudes are less then 45. Say, As *A B*, the cosine of the difference of longitude 55, is to *A C* the Radius, so is B D the Tangent of 30, one of the latitudes, to *C E*, the Tangent of 35. 10, whose complement 54. 50 being deducted out of the other latitude, 10 and 90 added together, to wit 100, the remainer will be 45. 10, then say, As F G, the sine of 35. 10, the ark found, is to F C the cosine of 45. 10, to wit 44. 50, so is G H the sine of the latitude first taken, 30, to C I the sine of 37. 44, whose complement 52. 16 being reduced, gives 1045 leagues 1 mile, or 3136 miles, the distance required.

One example more will make all plain, and that shall be of two places, the one having 70 degrees of South latitude,

and the other 40 degrees of North, and whose difference of longitude is 50 degrees, so use this following proportion.

As A B, the cosine of 50, the difference of longitude, to wit 40, is to *A C* Radius: *So* is B D the Tangent of the lesser latitude 40, to *C E*, the Tangent of 52. 32; whose complement 37. 28, being deducted out of the other latitude 70, and 90 degrees added together, to wit, 160 degrees, the remainer will be 122. 32, whose complement to a semicircle, or 180 degrees, to wit 57. 28, is the same as 122. 32, (which you are to take notice of this hapning oftentimes.) Then proceed by this proportion, *As* F G, the sine of 52. 32, the ark found, is to F C, the cosine of 57. 28; the ark remaining, to wit 32. 32, *So* is G H the sine of the lesser latitude 40, to C I, the sine of 25. 49, whose complement 64. 11 gives 1283 leagues 2 miles, or 3851 miles the distance required.



MVSEVM
BRITAN
NICVM

FINIS.

Courteous Reader, *Theſe Books following are Printed and ſold by* Thomas Pierrepont, *at the* Sun *in St.* Pauls Church-yard.

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Aſtronomia Britannica, Exhibiting the Doctrine of the Sphere, and *T*heory of the Planets decimally, by Trigonometry, and by Tables fitted for the Meridian of *London*, according to the Copernican Syſtem, as it is illuſtrated by *Bullialdus*, and the eaſie way of Calculation, lately publiſhed by Dr. *Wards*.

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and perticular, each of them accommodated for Dialling, for the resolving of all Proportions Instrumentally; and for the ready finding the hour and Azimuth universally in the equall limbe; of great use to Seamen, and practitioners in the Mathematicks: by *John Collins* Account. Philomath.

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